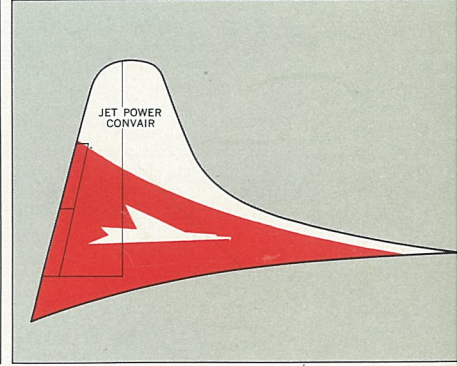
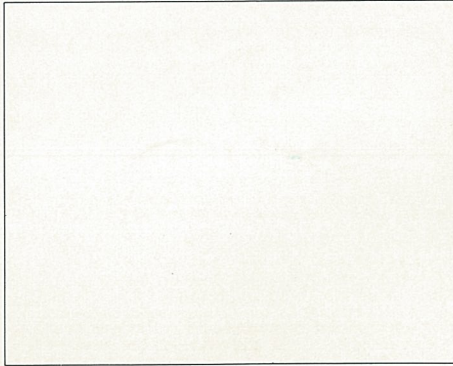
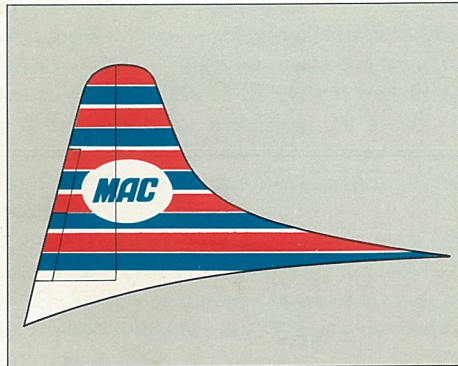
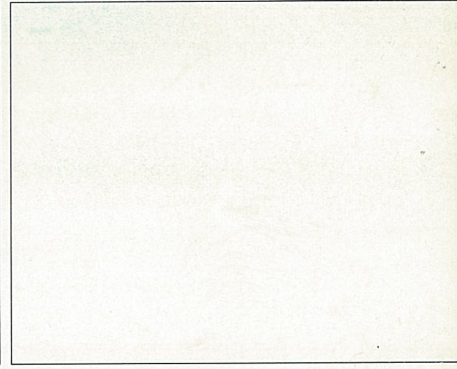
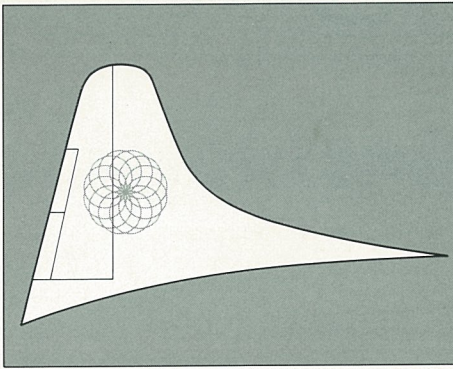
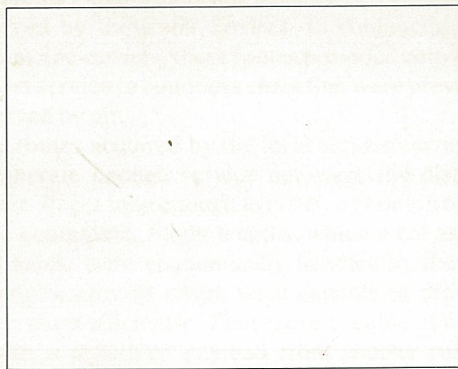
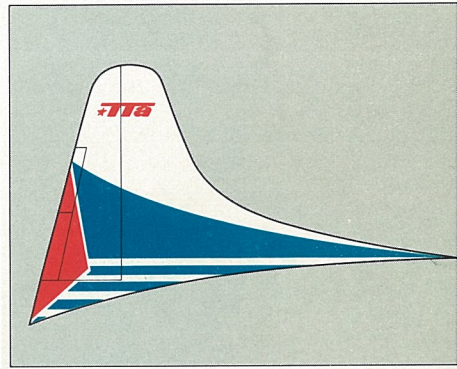
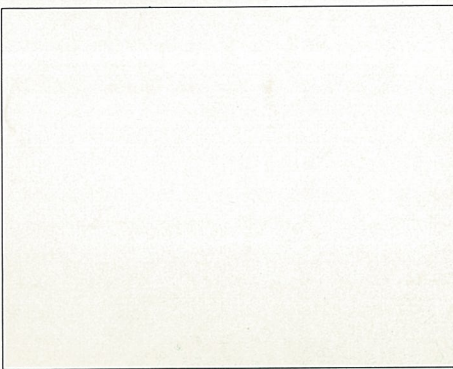
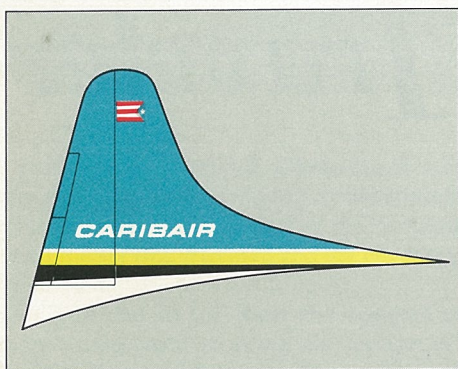


VOLUME XIX    NUMBER 1    MAY/JUNE 1966

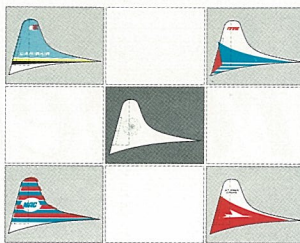
# Convair *Traveler*



*In This Issue: Regional and Local Service Airlines  
Using the Convair 600/640*

VOLUME XIX NUMBER 1 MAY/JUNE 1966

## Convair *Traveler*



*In This Issue: Regional and Local Service Airlines  
Using the Convair 600/640*

### OUR COVER

Tony Adams, artist, attractively displays the aircraft insignia for all airlines presently operating Convair 600/640's, the Convair-Liners modified for installation of Rolls-Royce Dart R.da.10 turboprop engines.

# Convair *Traveler*

VOLUME XIX NUMBER 1 MAY/JUNE 1966

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### IN THIS ISSUE

PAGE 3

## REGIONAL & LOCAL SERVICE AIRLINES USING 600/640

A digest of operation and service published monthly by the Technical Publications Section of GD Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

## *A Salute to Local Service and Regional Airlines Operating the Convair 600/640*



Thirty years ago, local service airlines began operation on a trial time-limit basis. Original certification was for a three-year period, and renewal of the certificate depended on the service provided and the number of passengers carried.

Routes awarded to the local and regional service airlines were designed to bring air service to small communities that could not feasibly or economically be served by the trunk carriers. In conjunction with the trunkline carriers, these routes provided convenient low-cost service to countless cities that were previously not served by air.

The routes acquired by the local service carriers did not generate enough service nor were the distances between stages long enough to justify operation of four-engine equipment. Flight lengths, which were as short as 50 miles, were economically handled by the small twin-engine aircraft which were capable of providing service more efficiently. They were capable of operating with a profitable payload from shorter runways than could four-engine equipment.

Today, local service and regional airlines deliver approximately 40% of their passengers a year to connecting trunklines. This is of mutual benefit to both carriers, the trunklines supplying the locals with as many interconnecting passengers as they receive.

Many Convairs are in operation on local service and regional routes.

The Convair-Liner commercial fleet, now numbering about 515 aircraft, and a military fleet of 492, have an enviable history of service. Many of the commercial aircraft are still in the hands of the original purchasers. The first and largest purchaser of Convair 240's recently sold their last aircraft to a regional airline. This transition from a trunk carrier to a local service airline

is typical of the route a large number of Convairs have taken—sometimes via several airlines along the way. Local and regional carriers in the United States alone, are operating more than 165 Convairs.

There has been a slow but continuing transfer of Convairs from trunk carriers to regional and service carriers. These airlines are growing and will have to provide better service for local communities without a gross increase in operating cost.

The Rolls-Royce Dart conversion, offered by Convair, provides the most economical up-dating of equipment available anywhere. This modern turbo-powered short-range transport, which offers unmatched economy, reliability, and earning power, costs a fraction of comparable new aircraft. It is sized for the short range segment of the airline market.

Convair aircraft are fully stressed to permit operation at the higher speeds made possible by installation of the Rolls-Royce Dart engines. Where the acquisition of new aircraft presented a major financial outlay, the Dart-powered aircraft offers a modern fast, turbine transport at roughly half the price of new turbine-powered equipment. This unique situation exists because the basic airframe is usually depreciated or partially depreciated at the time of conversion. Therefore, instead of raising capital to purchase the entire aircraft, it is necessary only to finance cost of the conversion.

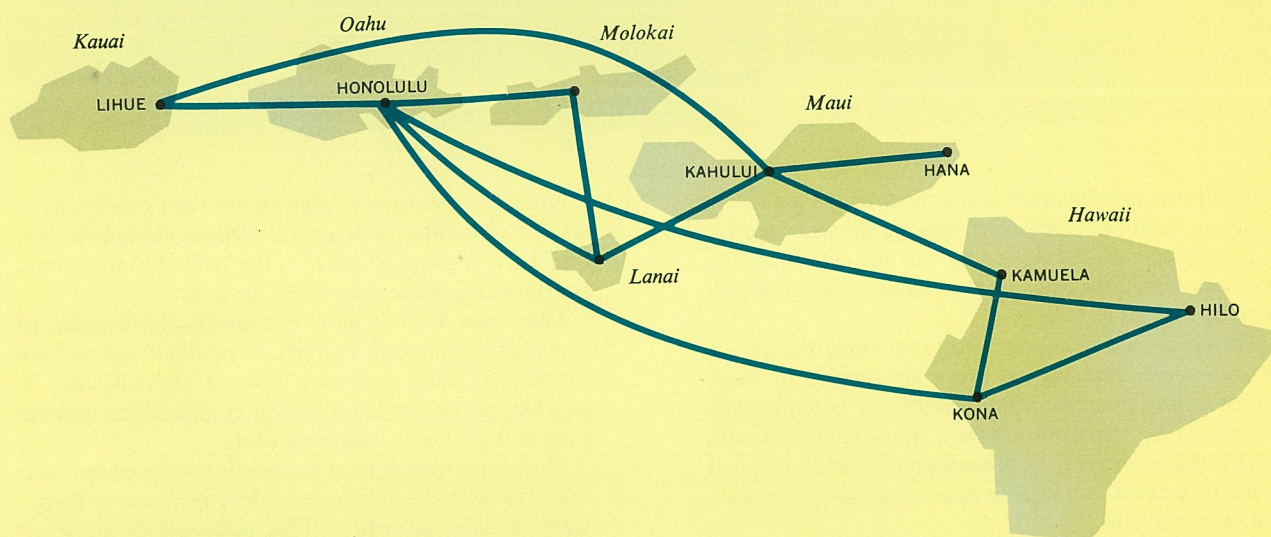
Since the airframe has demonstrated its ruggedness and durability throughout its history, another 10 to 20 years of economical service life is possible after the conversion.

Combining passenger appeal with greater operational flexibility, the modified aircraft is expected to generate increased revenue for the local service and regional airlines with a decrease in operating cost.



# HAWAIIAN AIRLINES

*...holder of the world's safety record...*



HAL entered the commercial airline field in 1929 when it made its first flight as Inter-Island Airways, operating twin-engine Sikorsky S-38 amphibians. Since that time, HAL has carried more than ten million passengers and flown over one billion two hundred million passenger miles. This amounts to a lot of flights when you consider that Hawaiian has a route pattern of less than 400 miles, with the average passenger traveling 125 miles.

While not strictly classified as a local service airline, HAL provides local service throughout the Hawaiian Islands, scheduling more than 75 flights daily with its fleet of DC6B's, DC3's, and Super Convairs.

Nearly 98 per cent of all air cargo in the islands is carried by HAL. In 1965 this airline carried two and one-half million ton-miles of air freight. This was made possible by an air cargo certificate granted by the CAB in 1942, making HAL the first scheduled carrier in the United States to be granted such a certificate.

HAL is justly proud of the fact that its inter-island routes are over some of the most exotic, eye-tempting

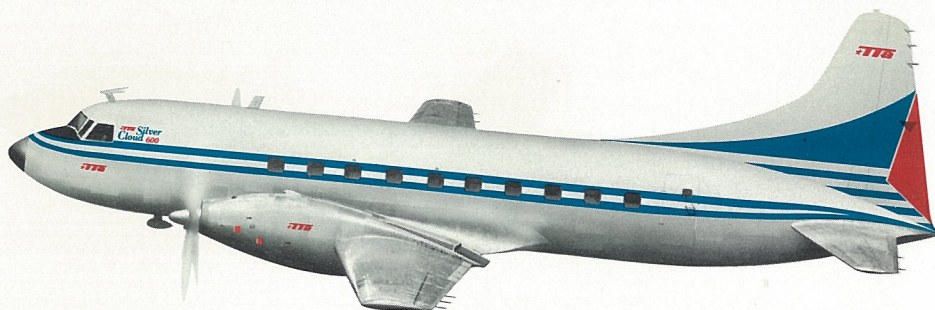
attractions in the world. Virtually all flights are over water. Its passengers look down on a wide variety of scenic beauty over the blue Pacific and six islands in the Hawaiian Island chain.

This airline's promotion efforts have done much to attract visitors to the beautiful garden islands.

Home base for HAL, and the principal port of call for oceanic aircraft and ships, is at Honolulu International airport on the island of Oahu. From here, Hawaiian bridges the chain of islands with its aerial transportation system.

HAL's first Convair 640, modified at the Convair Service Center, entered inter-island service on 23 December 1965. Service was expanded by delivery of the second 640 on 8 February 1966. These aircraft are being used seven hours and fifty minutes a day in heavy weekend traffic.

Hawaiian's vision, imagination, and determination have been instrumental in expanding foreign trade and travel to and from five continents and the Mainland United States. Progress is continually in Hawaiian's planning.



## TRANS★TEXAS airways

*...With the Silver Cloud 600, TTA keeps step with progress in the great southwest...*

TTA began service in 1947, when two DC3's flew some 695 miles across the state of Texas, stopping at eight cities. In 1952, five years later, the airline flew 78,214 passengers a total of 18.3 million miles. By 1963, this figure had climbed to 457,450 passengers and 106.4 million miles.

Today, TTA's routes fan westward throughout New Mexico and eastward through Arkansas and Louisiana, and into Tennessee and Mississippi, to link the shortest and straightest thoroughfares in six states and 48 communities, making TTA a vital part of the network of the southwest air traffic.

With expansion and development came the need for new and more equipment. Convair-Liner 240's were purchased from American Airlines to supplement TTA's fleet of 23 DC3's.

The decision to convert their 240's to turbine power was based on several factors. TTA's present 40-passenger, pressurized, and radar-equipped aircraft proved to be the type of aircraft best suited to the airline's system. Turboprop engines and other improvements in the aircraft as a result of the conversion were expected to provide the greatest amount of improvement in service to all cities.

Weighed, too, was the fact that only a limited number of new aircraft could be purchased and put into service for the same amount of money expended to

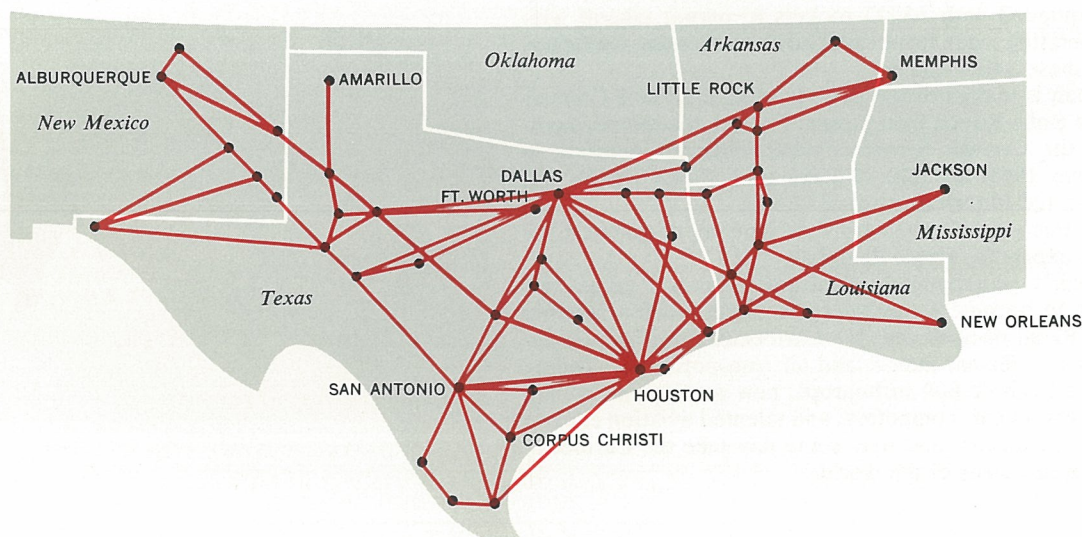
convert 25 Convairs. These few new aircraft could not provide the frequency and convenient schedules provided by a large fleet of Convair 600's.

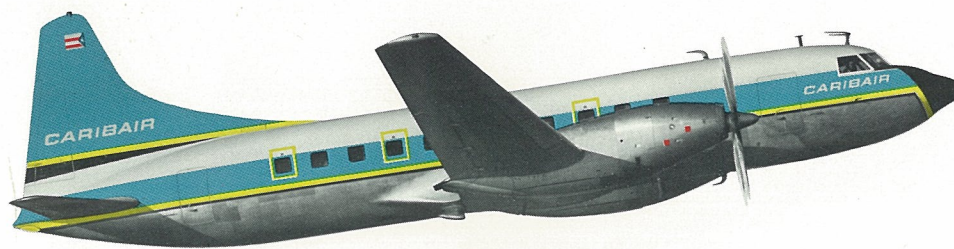
The airplane with Rolls-Royce Dart engines was admirably suited for TTA's route structure. No other type aircraft in operation or being developed promised such low cost per passenger mile. This, together with the advantages of higher speed and greater passenger comfort, made it the inevitable choice.

TTA, at their Houston maintenance base, completed conversion of, and flew, their first Convair 600 on 22 January 1966, averaging 9 hours per day in pilot training. Passenger service began over selected routes on 1 March with a scheduled utilization of 11:15 hours per day.

TTA has long been a leader among local service carriers. For its record for on-time service, efficiency, and economy, it has earned the airline the distinction of recording the highest on-time performance percentage of any airline in the United States.

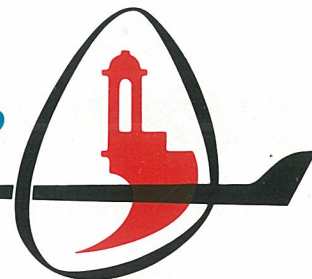
The infectious team spirit, which prevails throughout the organization has contributed to the success of TTA. The friendly symbol of Pamper Belle with the slogan, "The extra touch of service", which has always been so much a part of TTA, is really an invitation to travelers to avail themselves of the facilities of the airline and be pampered.



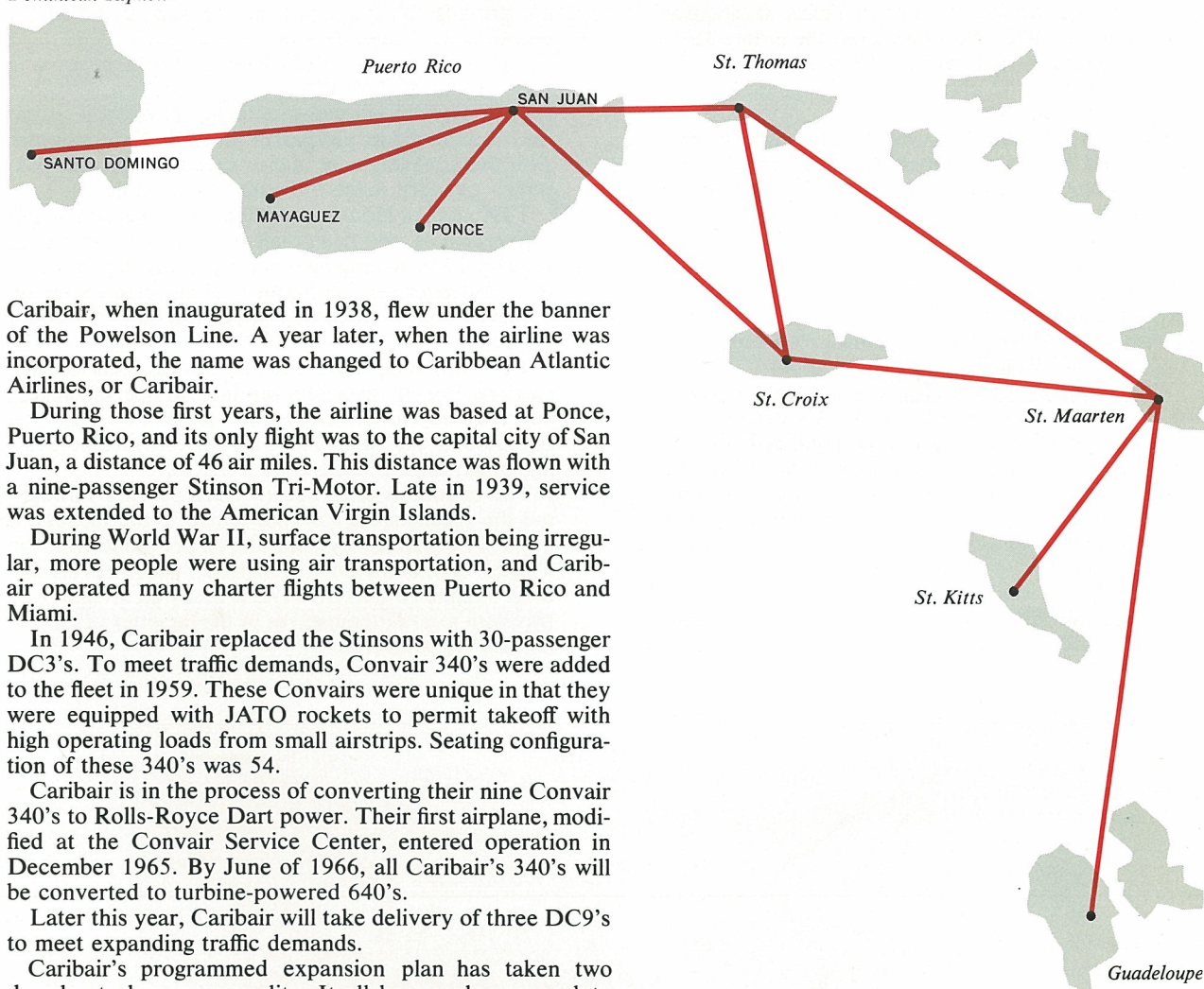


# CARIBAIR

*U.S. flag carrier in the Caribbean*



*Dominican Republic*



Caribair, when inaugurated in 1938, flew under the banner of the Powelson Line. A year later, when the airline was incorporated, the name was changed to Caribbean Atlantic Airlines, or Caribair.

During those first years, the airline was based at Ponce, Puerto Rico, and its only flight was to the capital city of San Juan, a distance of 46 air miles. This distance was flown with a nine-passenger Stinson Tri-Motor. Late in 1939, service was extended to the American Virgin Islands.

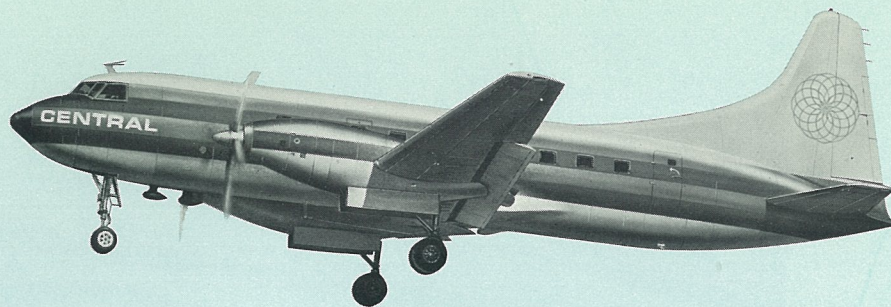
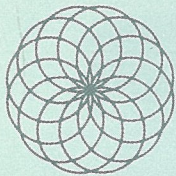
During World War II, surface transportation being irregular, more people were using air transportation, and Caribair operated many charter flights between Puerto Rico and Miami.

In 1946, Caribair replaced the Stinsons with 30-passenger DC3's. To meet traffic demands, Convair 340's were added to the fleet in 1959. These Convairs were unique in that they were equipped with JATO rockets to permit takeoff with high operating loads from small airstrips. Seating configuration of these 340's was 54.

Caribair is in the process of converting their nine Convair 340's to Rolls-Royce Dart power. Their first airplane, modified at the Convair Service Center, entered operation in December 1965. By June of 1966, all Caribair's 340's will be converted to turbine-powered 640's.

Later this year, Caribair will take delivery of three DC9's to meet expanding traffic demands.

Caribair's programmed expansion plan has taken two decades to become a reality. It all began when a resolute Puerto Rican decided that the Caribbean's growth was dependent on efficient inter-island air transportation. Today, jets, and Convair 640 turboprops, new routes, one million passengers a year, computers, and talented aviation experts link the Caribbean, and may some day take the Caribbean area to other areas of the world.



# CENTRAL AIRLINES

*...serving the heart of the nation...*

Central Airlines in the land of oil and wheat serves the heart of the nation. It is a major south-midwest local service carrier, linking the trade territory of the upper midwest with the oil empire of the southwest.

Central Airlines serves some of America's most dynamic modern metropolitan areas — Kansas City, Dallas, Ft. Worth, Little Rock, Oklahoma City, St. Louis, and Denver. This fast-growing, modern airline does an excellent job of putting convenient air travel within geographical and economical reach of the people it serves.

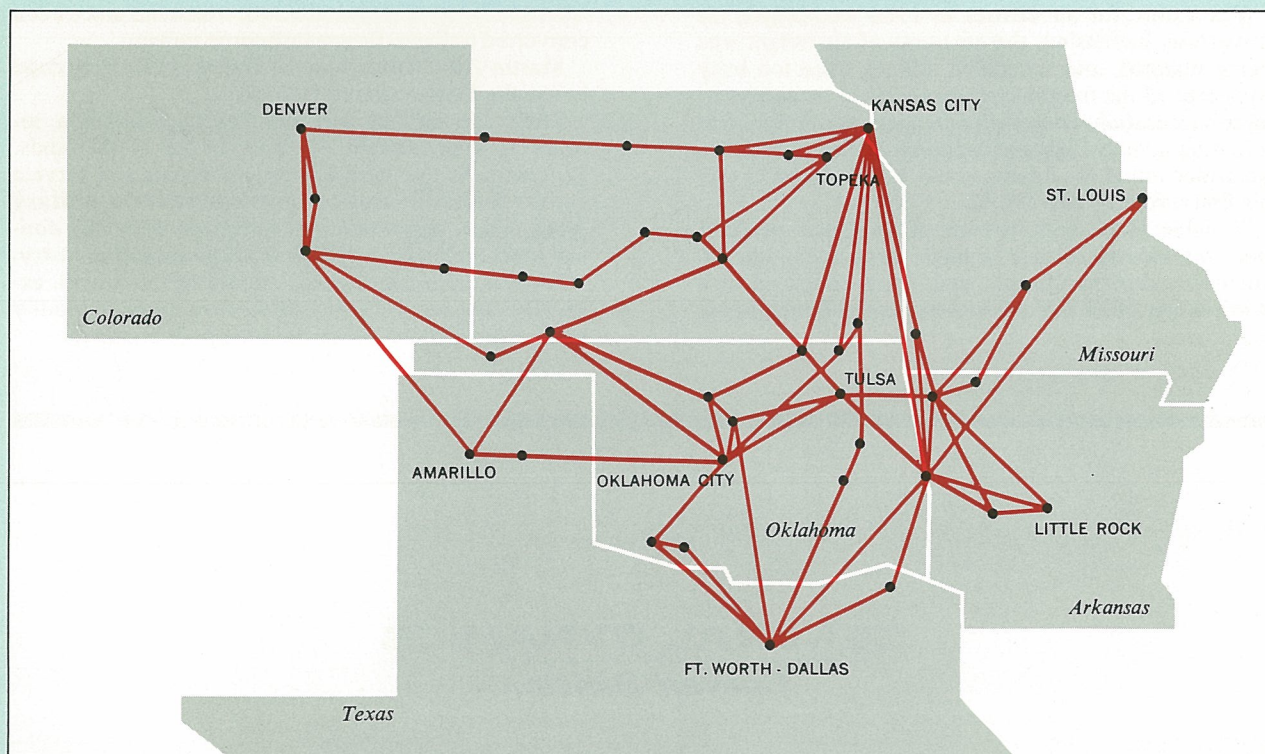
Central Airlines, on 30 November 1965, was the first local service airline to inaugurate Convair 600 passenger service, with schedules between Ft. Worth and St. Louis.

With conversion of its Convair-Liner 240's to Rolls-Royce Dart engines, Central is equipped to handle

more of the short-haul trunk routes that are gradually being turned over to the local service (regional) carriers.

In 1949, Central began operation carrying 54 passengers in its first month of operation. Today, this fast-growing modern airline carries over 40,000 per month over its six-state area of Colorado, Kansas, Oklahoma, Arkansas, northern Texas, and Missouri.

Central entered the commercial field determined to provide a service that would equal that of any airline in the country. It was, and still is, the aim and desire of the Central family to build and maintain a reputation for efficient, courteous, safe operation, and to offer the best equipment available for these short-haul routes. This thinking has been rewarded with growth and prosperity, and the traveling public has given Central its confidence and support.





# MARTIN'S AIR CHARTER

*...An essential link in the chain of world transport...*

Martin Air Charter (MAC) was founded on the principle that an air charter service could fill air traffic requirements that could not feasibly be filled by scheduled airlines.

Martin Air Charter was founded on 24 May 1958, when Martin Schröder, having served in the Royal Dutch Air Force, and later was active in flying advertising signs over the Netherlands, made a contract with a grower to transport a load of flowers in a chartered airplane. The satisfying results of this first charter, and the interest of Dutch industrialists in a charter service, convinced Martin Schröder to carry on with his ideas.

The future for air charter in 1960 was bright; air travel was increasing, the economy of air freight was being realized, and scheduled airlines were too busy to accept all the freight available to them. In this year, after successfully carrying passengers and freight and initiating holiday flights with chartered aircraft, Martin Schröder found his finances sufficiently sound to buy his first aircraft—two DC3's.

Reliable MAC with its team of dedicated men carried this charter service through many seemingly insurmountable problems; yet, they operated at a profit when other major airlines were suffering financial losses.

Air Charter was not a new venture, but Martin Schröder's approach to it was new and different. He operated to the same standards as the scheduled airlines, except as required to meet the requirements of a charter service.

In 1963, MAC extended routes and operated as a feeder-line for intercontinental flights sponsored by large companies. With this expansion came the acquisition of more aircraft to take care of trans-Atlantic flights to South America and Newfoundland. The interest of four Dutch shipping companies was another "shot in the arm" for MAC.

In 1964, MAC acquired a 340, which has since been converted to Rolls-Royce turboprop power.

Martin Air Charter was the first operator in Europe to use the Dart-powered Convair.

Their 340 aircraft was modified by Aviоланда, located at Woensdrecht Air Base in the Netherlands. Aviоланда is the official approved repair and service center for major civil aircraft and several military types. Their know-how and standards of quality control meet the highest standards in the aircraft industry.

Aviоланда, being a complete aircraft overhaul, assembly, and repair facility, is well equipped to modify other Convair aircraft on the European continent.

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**GENERAL DYNAMICS**  
*Convair Division*

VOLUME XVIII    NUMBER 2    JULY/AUGUST 1966

# *Convair* *Traveler*

11 44



*In This Issue: Rubber*



## FOR THE COVER

### OUR COVER

Willis Goldsmith, artist for this issue, had to stretch his imagination to come up with the snappy ideas he used to portray rubber in this issue. We can vouch for it—he wasn't potted when he drew those rubber plants.

# Convair Traveler

VOLUME XVIII NUMBER 2 JULY/AUGUST 1966

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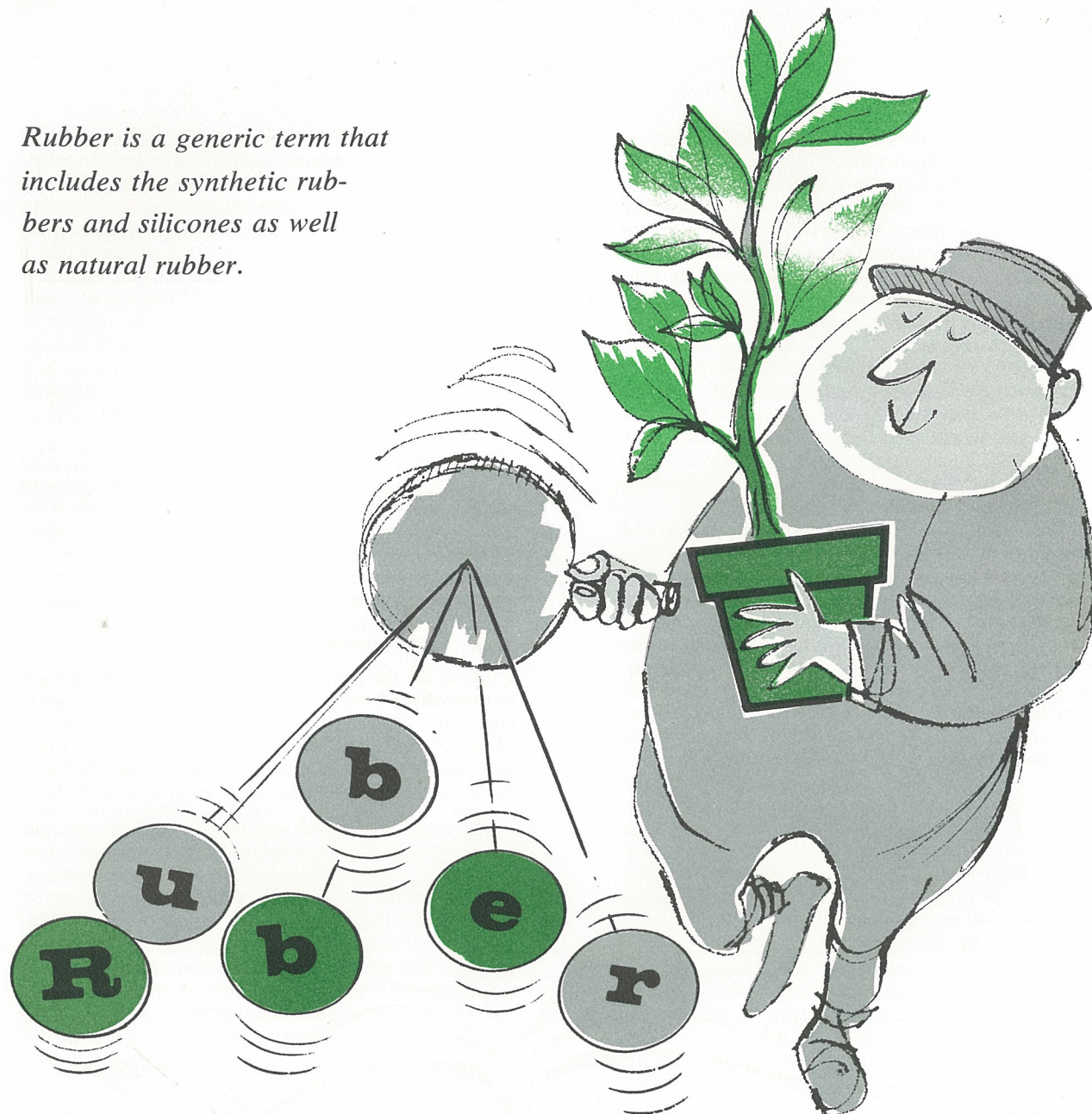
RUBBER

BACK COVER

U.S. COAST GUARD  
TO USE  
TELEMETERING  
BUOY SYSTEM

A digest of operation and service published monthly by the Technical Publications Section of GD Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

*Rubber is a generic term that includes the synthetic rubbers and silicones as well as natural rubber.*



\*Rubber is used throughout the aircraft industry to prevent the entrance of dirt, water, and air, and to prevent the loss of fluids, gases, and air. It is also used to absorb vibration, reduce noise, and cushion impact loads.

Aircraft tires were discussed in the November/December 1964 issue of the Traveler. This article will discuss other uses of rubber in aircraft, with particular emphasis on seals.

Seals fall into two categories: static and dynamic. Static seals are those in which the sealing surfaces are not subject to movement relative to each other; dynamic seals are those in which one of the seal surfaces moves in relation to the other. Examples of static seals are gaskets on hatches and doors, and weatherstripping on windows; examples of dynamic seals are O-rings in reciprocating cylinders or hydraulic actuators.

\*The word "rubber" is used to include not only natural rubber, but all synthetic rubbers and silicones unless specifically designated by type.

A seal must be pliable, yet compressible, and must distort to increase sealing efficiency as pressure is increased. It must meet such requirements as low compression set characteristics; elasticity; ozone, weather, and age resistance; high and low ambient temperatures with low temperature flexibility; resistance to petroleum and hydrocarbons; tensile strength; and tear resistance.

Seals in early aircraft were of natural rubber. Natural rubber has excellent physical properties but it swells and softens in petroleum and hydrocarbon products, in naphthas and some solvents.

With the increasingly extreme temperature ranges encountered in a modern flight schedule from sea level (hot day) to 50,000 feet, and with increased cabin pressures of high-altitude aircraft, the requirements for sealing materials have become increasingly difficult. Moreover, new improved fuels and fluids impose greater oil- and chemical-resistant requirements on the seals.

In order to meet these increasing requirements, a large number of synthetic rubbers have been developed during the past 30 years. The first of the synthetic rubbers were specialty rubbers which were specifically developed to overcome some serious deficiency of natural rubber, such as poor solvent resistance. These early specialty rubbers were later augmented by general purpose rubbers such as Buna S and, more recently, stereo-specific polymers, such as polyethylene-propylene rubbers.

As a result of this tremendous development in polymer chemistry during the past three decades, rubbers are presently available that function from  $-150^{\circ}$  to  $+600^{\circ}\text{F}$ , and which are resistant to everything from the molten alkali metal to the most polar high-solvency fuel or lubricant. Similarly, rubbers are available which resist environmental exposure indefinitely.

Unfortunately, none of the superlative physical and chemical properties mentioned are all contained in the same "super-rubber." Physical and chemical properties are related in the molecular structure; for example, rubbers having highly polar groups or atoms along the macromolecular chain backbone, are physically strong and tough and have good resistance to non-polar liquids such as petroleum and gasoline. By the same token, these polymers are readily attacked by polar solvents; that is, by lubricants and fuel also having highly polar groups or atoms similar to those along the polymer chain. Thus, the old principle that "like dissolves like" precludes finding a rubber that is universally resistant to all solvents. Similarly, although less obviously, the enhancement of one physical property is usually accompanied by a decrease in some other physical property. For example: polyurethanes are polyether or polyester groups joined into a cross-linked matrix by the highly polar urethane and urea groups.

The attraction of these polar groups for each other produces strong intermolecular forces, and the polyurethanes exhibit superior tensile strength and abrasion resistance. This same strong intermolecular bonding also results in high mechanical hysteresis (heat buildup during flexing), and the modulus has a high temperature coefficient, stiffness and hardness changing rapidly with temperature. Moreover, although the polar urethane/urea groups are almost completely unaffected by non-polar solvents, such as gas and oil, they are greatly affected by the polar solvents such as water and acetone; thus, polyurethanes are attacked by the very solvents toward which natural rubber is so resistant.

The most widely used synthetic is Buna S, otherwise known as GRS or SBR. More than a million long tons are produced in the United States. In fact, Buna S together with natural rubber accounts for nearly 90% of the total world rubber consumption. Certain newer synthetics, such as EPR (ethylene propylene rubber), and stereo polybutadiene, as well as a wide range of polyurethane, show promise of eroding this present Buna S natural rubber dominance.

These are the general purpose rubbers that are used in everything from auto tires to mechanical products, and from protective coatings to upholstery cloths. Many of these are also important sealing materials; particularly GRS, which is used with automobile brake fluids, and EPR with phosphate ester hydraulic fluid.

The aircraft engineer and mechanic, however, are much more likely to encounter specialty rubbers such as Buna N, butyl, neoprene, silicone, fluoroelastomers, and polysulfide rubbers. Of these, Buna N, or nitrile rubber, is by far the most important, comprising two-thirds of all common military and AMS O-ring compounds. The nitrile rubbers owe their preeminence in



the seal industry to their excellent oil resistance and ability to be compounded for service over a temperature range of  $-65^{\circ}$  to  $250^{\circ}\text{F}$ .

The specific characteristics of more important specialty rubbers will be discussed in detail later in this article.

It should be apparent by now that the term "rubber" is about as all-inclusive as the term, "metal." There are at least 15 basic types of rubber and, since most of these are copolymers or terpolymers (composed of two or three chemical constituents, loosely analogous to alloys in metallurgy), the physical and chemical behavior of each of these copolymers will change as the relative chemical compositions change. This is well illustrated in Table I for a series of Buna N rubbers. Buna N is a copolymer of butadiene (a non-polar hydrocarbon building block) and acrylonitrile (a very polar nitrogen containing a building block).

TABLE I  
VARIATION OF BUNA-N PROPERTIES  
With Chemical Constitution

|                       | Acrylonitrile<br>15% (low) | Copolymer<br>25% (med) | 35% (high)           |
|-----------------------|----------------------------|------------------------|----------------------|
| Refractive Index      | 1.54                       | 1.52                   | 1.54                 |
| Density (%)           | 0.96                       | 0.98                   | 1.00                 |
| Swell in Kerosene (%) | 10%                        | 8%                     | 4%                   |
| Swell in Aviation Gas | 60%                        | 100%                   | 150%                 |
| Tensile Strength      | 500 psi                    | 700 psi                | 900 psi              |
| Elongation            | 400%                       | 400%                   | 500%                 |
| Brittle Point         | $-40^{\circ}\text{C}$      | $-30^{\circ}\text{C}$  | $-1^{\circ}\text{C}$ |
| Elastic Resilience    | —                          | 74%                    | 63%                  |

As the ratio of polymer acrylonitrile to the non-polar monomer (butadiene) increases, certain properties are enhanced while others are diminished. Tensile strength and oil resistance increase while the brittle point and resilience decrease. Thus, Buna N changes from a highly elastic state to a less elastic rubber as acrylonitrile increases; in fact if the acrylonitrile content is increased above 50%, the copolymer will assume the properties of leathery plastic rather than those of rubber.

In order to convert raw rubber from gummy thermosensitive plastic to strong elastic engineering rubber, the base polymer must be compounded and vulcanized; that is, cross-linked into a three-dimensional network. These compounding agents are designed to improve or modify the physical and aging properties. Compounding agents include vulcanizing agents, such as sulfur and activators; softeners (or plasticizers); and protectants (such as antioxidants, antiozonants, and antirads).

Obviously, a master compounder can produce hundreds of different rubbers, each having significantly different physical properties, from the same basic elastomer or rubber. Changes produced by variations in compounding can be tremendous. For example, by simply increasing the extent of vulcanization, natural rubber can be changed from soft weak eraser stock to a tough strong tire stock, and finally to a hard ebonizer.



After vulcanization, fillers are the single most important ingredient. With the exception of silicones and fluorocarbon rubbers, the greatest increase in tensile strength and abrasion resistance is achieved by incorporating carbon black. With synthetic polymers, this can result in as much as a six- to ten-fold increase in tensile strength.

As indicated, almost any rubber can be compounded to almost any degree of hardness. Rubber hardness is essentially a measure of the resistance of rubber to deformation under load at moderate loading rates. This hardness is usually measured by an instrument called a Durometer, the results being explained in terms of Shore A units from 0 to 100; the higher the reading the harder the rubber.

To illustrate, Durometer hardness of a few familiar rubber objects is given.

| Object                    | Shore A Hardness |
|---------------------------|------------------|
| Art Gum Eraser            | $30 \pm 5$       |
| Rubber Band               | $40 \pm 5$       |
| Rubber Stamp Letters      | $50 \pm 5$       |
| Pencil Eraser             | $60 \pm 5$       |
| Rubber Heel               | $70 \pm 5$       |
| Rubber Sole               | $80 \pm 5$       |
| Typewriter Roll           | $90 \pm 5$       |
| Pipe Stem or Battery Case | $100 \pm 5$      |

The Durometer reading and AMS or MIL number of various types of rubber are given in Table II.

TABLE II

## Durometer Readings of AMS/MIL Numbers

AMS # HARDNESS SPECIFICATION

|      |      |   |
|------|------|---|
| 3195 | Med  | Closed cell sponge rubber   |
| 3196 | Firm | Closed cell sponge rubber   |
| 3197 | Soft | Chloroprene type synthetic weather-resistant sponge—aromatic fuel resistant, low swell            |
| 3198 | Med  |   |
| 3199 | Firm |   |
| 3200 | 60   | Petroleum base, hydraulic fluid-resistant   |
| 3201 | 40   | Dry heat-resistant to 300°F; medium oil resistant   |
| 3202 | 60   |   |
| 3204 | 30   | Low temperature resistance (– 70°F)   |
| 3205 | 50   |   |
| 3206 | 70   | Extreme-pressure, lubricant-resistant   |
| 3207 | 30   | Weather-resistant chloroprene, low loss in tensile and elongation after aging at 212°F.           |
| 3208 | 50   |   |
| 3209 | 70   |   |
| 3210 | 70   | Electrical-resistant, chloroprene type  |
| 3211 | 60   | Coolant resistant   |
| 3212 | 60   | Aromatic fuel-resistant, low swell, low shrinkage   |
| 3213 | 80   |   |
| 3214 | 40   |   |
| 3215 | 70   |   |
| 3220 | 60   | Fuel- and hot-oil resistant   |
| 3221 | 50   | Rapid swelling in fuel  |
| 3222 | 50   | Hot-oil resistant, high swell   |
| 3226 | 50   | Hot-oil and coolant-resistant up to 300°F; low swell, good compression set                        |
| 3227 | 60   |   |
| 3228 | 70   |   |
| 3229 | 80   | Hot-oil resistant, low swell  |
| 3230 | 80   | Oil resistant; ideal for gasketing  |
| 3231 | 80   | Oil resistant; with synthetic rubber binder   |
| 3232 | 80   | Asbestos and synthetic sheet; oil-resistant   |
| 3237 | 40   |   |
| 3238 | 70   | Synthetic rubber, butyl type, phosphate ester resistant   |
| 3239 | 90   |   |
| 3240 | 40   | Weather-resistant chloroprene type; low loss in tensile and elongation after heat aging to 212°F. |
| 3241 | 60   |   |
| 3242 | 80   |   |
| 3245 | 40   |   |
| 3246 | 50   | Buna S type   |
| 3247 | 60   |   |
| 3250 | 40   | Soft  |
| 3251 | 50   | Med Synthetic rubber and cork combination, general purpose  |
| 3252 | 60   | Firm  |
| 3270 | 60   | Synthetic rubber sheet, cotton fabric reinforced, chloroprene type                                |
| 3274 | 60   | Buna N rubber sheets, nylon reinforced, aromatic fuel resistant                                   |
| 3301 | 40   | General purpose silicone rubber   |

AMS # HARDNESS

SPECIFICATION

|      |       |  |
|------|-------|--|
| 3302 | 50    | Silicone rubber, general purpose, heat and weather resistant at temperatures of – 65° to + 400°F; for O-rings and gaskets in contact with petroleum products; good combination of elongation and tear resistance, plus oil resistance. |
| 3303 | 60    |  |
| 3304 | 70    |  |
| 3305 | 80    |  |
| 3315 | 80    | Silicone rubber sheet, glass fabric reinforced.  |
| 3320 | 70    | Silicone rubber sheet, glass fabric reinforced, heat and weather resistant   |
| 3332 | 15-30 | Silicone, extreme low-temperature resistance; good physical properties; flexibility at extremely low temperature   |
| 3334 | 40    |  |
| 3335 | 50    |  |
| 3336 | 60    |  |
| 3338 | 80    |  |
| 3345 | 50    | Silicone (colors). Excellent elongation and tear resistance; very low water absorption and fair oil resistance.  |
| 3346 | 60    |  |
| 3356 | 60    | Silicone, lubricating oil and compression set at high temperatures; extreme low temperature flexibility. Used for heat-resistant sealing rings in mechanical parts.  |
| 3357 | 70    |  |
| 7270 | 70    | Synthetic fuel resistant   |

MIL # HARDNESS

SPECIFICATION

|         |              |   |
|---------|--------------|---|
| C-1333  | Soft to Firm | RN, natural rubber, 10-15 sponge<br>RS, synthetic GRS, 21-28 foam (cored)<br>SB, Buna N, 31-34 foam (uncored)<br>SC, neoprene, 41-43 expanded |
| R-5847C | 40           | Class I silicone, extreme low temperature resistant   |
|         | 50           | Class I silicone, extreme low temperature resistant (– 150°F)   |
|         | 60           |   |
|         | 70           |   |
|         | 80           |   |
| R-5847C | 40           | Class II, high temperature resistant; red color   |
|         | 50           |   |
|         | 60           |   |
|         | 70           |   |
|         | 80           |   |
| R-6855  | 40           | Class I, aromatic fuel resistant; low temperature resistance to – 70°F  |
|         | 60           |   |
|         | 80           |   |
| R-6855  | 40           | Class II, synthetic oil resistant   |
|         | 60           |   |
|         | 80           |   |
| R-6855  | 40           | Class III, synthetic non-oil resistant  |
|         | 60           |   |
| R-6855  | 40           | Class IV, synthetic oil resistant for contact with acrylic plastics   |
|         | 60           |   |
| R-6855  | 60           | Class V, synthetic non-oil resistant for contact with acrylic plastics  |

## BASIC ELASTOMERS

Following are specific characteristics of natural rubber and the more widely used specialty rubbers.

### NATURAL RUBBER

Natural rubber exhibits the following superior processing and physical properties over synthetics and silicone rubbers: flexibility, elasticity, tensile strength, tear strength, and low hysteresis (heat buildup due to flexing or vibration). Natural rubber is a general purpose product; however, its suitability for aircraft use is somewhat limited because of its inferior resistance to most influences that cause deterioration. Although it provides an excellent seal for many applications, it swells and softens in all aircraft fuels, in many solvents, naphthas, etc.; and it deteriorates more rapidly than does synthetic rubber. It is recommended for use with water/methanol systems.

### SYNTHETIC RUBBER

Synthetic rubbers are available in several types, each type being compounded of different materials to give the desired properties. The most widely used are the butyls, Bunas, and neoprene.

BUTYL is a non-polar hydrocarbon rubber with superior resistance to gas permeation. It is also chemically stable and is resistant to deterioration; however, its physical properties are significantly lower than those of natural rubber. Butyl may be used to advantage in many applications where low gas permeation and resistance to chemicals and oxidation are more important factors than tensile strength or permanent set. Butyl will resist oxygen, vegetable oils, animal fats, dilute organic acids, alkalies, ozone, and weathering.

Like natural rubber, butyl will swell in petroleum or coal tar solvents. It has a low water-absorption rate and good heat and low temperature resistance. Depending on the grade, it is suitable for use in temperatures ranging from  $-65^{\circ}\text{F}$  to  $300^{\circ}\text{F}$ .

Although it has good resilience at elevated temperatures, it has poor resilience at room temperature, making it valuable for applications requiring absorption of energy. Its chief drawback is its lack of resistance to permanent distortion under load.

Butyl is recommended for use with phosphate ester hydraulic fluids (Skydrol), silicone fluids, gases, ketones, and acetones.

BUNA N (nitrile rubber) is outstanding in its resistance to hydrocarbons and other solvents; however, it has poor resilience in solvents at low temperature. Buna N compounds have good resistance to temperatures up to  $300^{\circ}\text{F}$ ; and may be procured for low temperature applications to  $-75^{\circ}\text{F}$ ; however, if extremely low-temperature properties are desired ( $-40^{\circ}$  and lower), some oil resistance must be sacrificed. On the other hand, if ultimate solvent resistance is desired, some low temperature properties must be sacrificed.

Buna N has fair tear, sunlight, and ozone resistance. It is usually designated where fuel and oil resistance is required and, as previously stated, is the most widely used rubber in the seal industry today.

BUNA S rubber resembles crude, or natural, rubber, both in processing and performance characteristics. Buna S is as water-resistant as natural rubber, but has somewhat better aging characteristics. It will deteriorate in sunlight even if the sunlight is filtered. It has good resistance to heat, but only in the absence of severe flexing. In comparison with natural rubber, Buna S has slightly lower tensile strength and test resistance; however, repeated flexure develops greater heat.

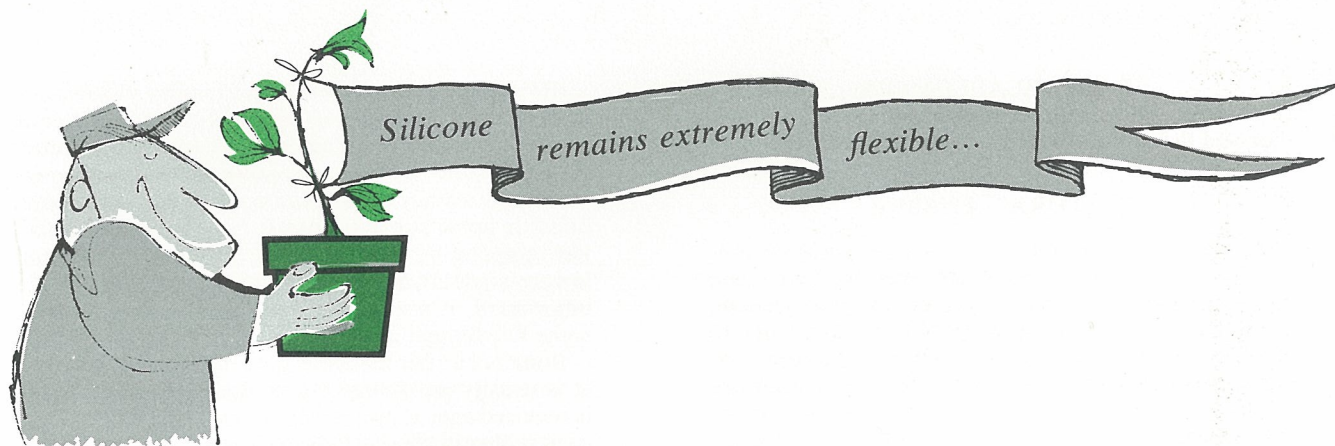
Generally, Buna S has poor resistance to gasoline, oil, concentrated acids and solvents (except oxygenated). It has good resistance to dilute concentrations of acid and alkali. It is equivalent to natural rubbers in all properties except elasticity and hysteresis.

GRS, which is a copolymerized Buna S at low temperature, is superior to natural rubber in abrasion resistance, and can be compounded to have a tensile strength equal to that of natural rubber.

THIOKOL, known also as polysulphide rubber, was originally developed by Thiokol Corp. The types which are most adaptable for use as gaskets and sealing devices are covered by the Thiokol PR-1 and ST types. These are basically made from ethylene dichloride and sodium tetrasulfide, or dichloroethyl ether and sodium tetrasulfide, or combinations of the two.

PR-1 and ST type Thiokols are true elastomers, possessing the best overall solvent resistance of any of the commercially available rubbers. These compounds, in general, are not seriously affected by petroleum, hydrocarbons, esters, ethers, kerosene, alcohols, gasoline, aromatic blended fuels, and water. Thiokols have good flexibility at low temperature and their properties remain stable, but tend to fall off at higher temperatures. They also have good aging characteristics.





On the other hand, the Thiokols are low in such physical properties as compression set, tensile strength, elasticity, tear and abrasion resistance, and are usually limited to sealant applications.

In general, Thiokol rubber is used to advantage in applications requiring a minimum of swell, and freedom from shrinkage; it has good aging characteristics when in contact with active solvents and reagents. In its application, physical properties are to be of secondary importance.

In processing, the Thiokols differ from natural rubber. They are milled with plasticizers and are not vulcanized with sulfur. They are usually cured with zinc oxide but cannot be cured to hard rubber.

NEOPRENE, or chloroprene (chemical designation), can take more punishment than natural rubber and has better low temperature characteristics. It possesses exceptional resistance to ozone, sunlight, heat ( $-70^{\circ}$  to  $250^{\circ}\text{F}$ ), and aging.

Neoprene looks and feels like rubber; laboratory analysis is required to tell them apart. Neoprene, however, is less like rubber in some of its characteristics than butyl and Buna. The physical characteristics of neoprene, such as tensile strength and elongation, are not equal to natural rubber but do have a definite similarity. Its tear resistance as well as its abrasion resistance is slightly less than that of natural rubber; although its distortion recovery is complete, it is not as rapid, with the probable exception of the type W neoprene.

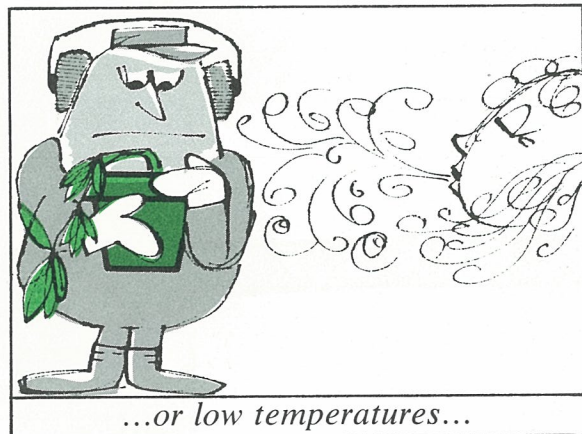
Neoprene has superior resistance to oil. Although it is good material for use in non-aromatic gasoline systems, it has poor resistance to aromatic gasolines.

Many of the well-known vegetable oils may be handled satisfactorily by this material, but mineral oils at low aniline point will cause most neoprenes to swell. Even so, their original physical properties are largely retained in this swollen condition. Oils with an aniline point over  $225^{\circ}\text{F}$  can usually be used with any neoprene. Neoprene solvent-resistance ranges from very poor to fair, depending upon the basic solvent involved. Another interesting quality about neoprene is its ability to withstand flame. Though it will ignite when held directly over a flame, it will not continue to burn when the flame is removed.

Neoprene is used primarily for weather seals, window channels, bumper pads, and chafing strips, which require good weather resistance. It swells moderately when in contact with oils and greases, but without affecting its usefulness. Neoprene is recommended for use with Freons and silicate ester lubricants.

SILICONE rubbers are a group of plastic rubber materials made from silicon, oxygen, hydrogen, and carbon. In the plastic form, the material has poor to fair mechanical properties, depending on the compounding.

Unlike organic rubbers, the silicones have excellent heat stability, which, combined with very low temperature flexibility, puts them in a class by themselves among rubber materials. In this capacity they are suitable for gaskets, seals, and other applications where elevated temperatures up to  $600^{\circ}\text{F}$  are prevalent. Silicone rubbers are also resistant to temperatures to  $-150^{\circ}\text{F}$ . Throughout this temperature range, silicone remains extremely flexible and useful with no hardness or gumminess; it is extremely resistant to deterioration.



Although this material has good resistance to oils with high aniline points, it reacts unfavorably to oils with low aniline points and to both aromatic and non-aromatic gasolines. Against solvents of the hydrocarbon types, excessive swelling occurs. It completely deteriorates if used in contact with steam under pressure.

The physical properties of silicone vary considerably with different formations. To enhance one or more properties often results in a sacrifice of performance in other properties. In general, other limitations of silicone include its relatively low tensile strength, tear resistance, ultimate elongation, and abrasion resistance at room temperature.

In general, wherever high or low operating temperatures, which could limit the life of organic rubbers, are encountered, the silicones will prove most useful.

Silicones are combined with various materials—Dacron, nylon, fiberglass, Teflon—to provide desirable characteristics. Dacron fabric provides high tear and abrasion resistance. Where a plain or close-weave dacron is used, a low-friction surface is obtained with high tear and abrasion resistance. It is suitable in applications where a seal, such as an airframe seal, moves across its mating surface. Dacron, however, limits the upper operating temperature of a seal. Fiberglass, on the other hand, withstands as high a temperature as the silicone, while providing flexible support. A loose tricot-knit fabric is similar to a close-weave covering except that it does not possess the low friction characteristics. Since it has the capability of stretching, it is suitable for door seals where it is required to stretch around corners without distortion.

Silicone coated with nylon is used at temperatures below 200°F.

A coating of Teflon film, with its slick surface, provides a low friction surface.

Silicone sponge rubber is used primarily for cushioning, weather-stripping, insulation, and for sound and vibration dampening. It provides high compressibility, or deflection, with low weight.

*Open cell* sponge rubber is a blown-up expanded mass of rubber. This type sponge rubber is used for vibration isolation, sound deadening, cushioning, and carpet underpadding.

*Closed cell* is also expanded but not to the extent of the open cell. This sponge rubber is resistant to liquid

absorption and gases, and is used for insulation and sound deadening. It does not withstand the severe compression characteristics of the open cell rubber.

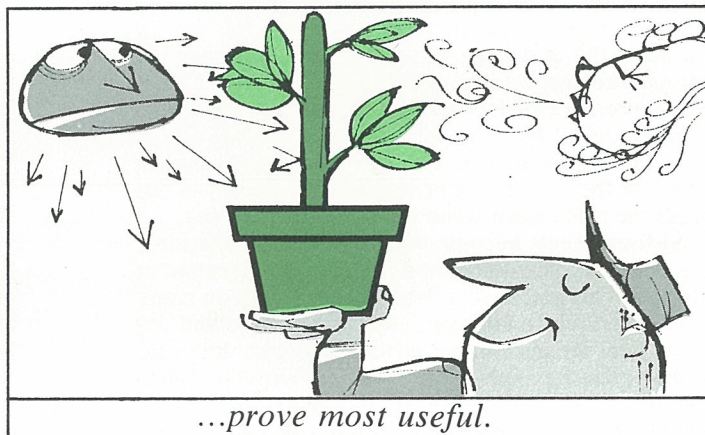
**SILASTIC®** (Dow Corning), one of the best known of the silicones is subdivided according to amount of filler and type of polymer for varied mechanical strengths. Silastic is used to insulate electrical and electronic equipment. Because of its dielectric properties over a wide range of temperatures and frequencies, it remains flexible and free from crazing and cracking. Silastic is also used for gaskets and seals in certain chemical and oil systems. Parts fabricated of Silastic give excellent service life at elevated temperatures. Silastic can be bonded to itself, to metal, glass, and ceramics.

**FLUOROSILICONE** is used primarily for parts requiring continuous operation in JP-4 and JP-1 jet fuels containing 5 to 30% aromatic additives, or in MIL-L-7808 synthetic lubricating oil. It is resistant to Skydrol in temperatures of -80° to 240°F, but is not recommended for use where Skydrol resistance is the primary concern.

**COHRLASTIC** is a silicone rubber product of the Connecticut Hard Rubber Company. It is a line of coated fabrics combining woven materials with silicone elastomers or resins in convenient form for a wide range of applications. The base material—orlon, dacron, fiberglass, etc.—must have the heat-resistant properties of the silicone polymers of at least equal temperature range. Fiberglass, fabric-coated with silicone, withstands high temperatures; orlon, on the other hand, is ideally suited for arctic temperatures and for flexural uses.

The high dielectric strength of the silicone resins at elevated temperatures is combined with the heat resistance of fiberglass for electrical uses. Cohrlastic pressure-sensitive tapes provide a void-free insulating jacket around cable, field coils, armatures, and other electrical devices.

A **FLUOROCARBON** elastomer that gives good performance at 400°F is Dupont Viton. It is resistant to lubricants, aromatic fuels, and hydraulic fluids at this temperature. It resists temperatures up to 600°F for short periods of time. Fluorocarbons have excellent resistance to deterioration, and can be used in contact with halogenated hydrocarbons, acids, silicate ester base lubricants, petroleum oils, and MIL-L-7808.



RTV silicone rubber, a product of General Electric Company, has found wide use as an adhesive, sealant, and for caulking. Packaged in convenient tubes, it is used in potting electrical terminal connections and for use as electrical insulation, for bonding silicone rubber gaskets to metal surfaces and for virtually all applications requiring a flexible and durable adhesive bond. This material can be bonded to most materials with a bond strength exceeding the strength of the rubber itself. These specially formulated products have elongations up to 200% even at temperatures to  $-150^{\circ}\text{F}$  and below. At the same time they provide long-term resistance to high temperatures, thus affording extended usage as thermal insulation. RTV materials cure at room temperature, after the addition of a curing agent, to form a durable and resilient protective silicone rubber.



#### MAINTENANCE OF RUBBER PARTS

Molded silicone (Shore 40A and 50A) reinforced with a fabric—usually dacron—is used for sealing entrance and service doors on high-performance aircraft. This material combines high strength with low temperature flexibility. The flex support seal installed on the passenger entry and service doors of Convair aircraft is constructed of high-strength silicone rubber, reinforced with two-way stretch dacron fabric. An inner and outer pressure wall precludes loss of pressurization in the event of unforeseen damage to the outer wall.

A flex support spring is molded within the seal to eliminate the possibility of seal collapse. This flexible spring wire supports the side-walls of the seal against lateral pressure loads, when pressurized, to assure positive alignment between the seal diaphragming crown and the fuselage striker. The fuselage striker is placed opposite the center line of the seal so that it will depress the seal crown when the door slides closed.

Airframe seals become very cold at high altitudes; then, can become quite hot if the airplane is parked in the sun. This can have a deteriorating effect on many seal materials. In addition, seals are inflated and deflated, and are chafed and scrubbed against the metal striker plate by slight movement in flight. To reduce friction and scrubbing wear, seals require a lubricant—a dry lubricant—such as molydisulfide (MIL-M-7866A).

These seals are vulnerable to damage any time luggage or material is moved through the opening. Too, on doors that are infrequently used the seal may adhere to the striker and, when the door is opened, some of the rubber may stick to the striker plate. This can be prevented by proper lubrication.

Seals are to be kept clean to extend their service life. Accumulations of dirt and foreign particles may cause excessive wear on the seal as it rubs on the striker plate. Dings and dents in the door frame and on the striker plate may render the seal incapable of compensating for normal variations in the sealing surfaces of the airframe and door, and for deflection caused by increasing cabin pressure.

For more information on the Flex-Support seal refer to July 1959 issue of *Traveler*.

Friction or sticking to the metal is one of the greatest sources of damage to O-rings. Assuming that the O-ring has been properly selected, then the only factors for combating friction are well-made and good-condition O-rings; proper packing squeeze; smooth metal surfaces; and proper lubrication. (Ref: Convair *Traveler*, May/June 1963 and July/August 1962.)

O-rings are selected by gland size which establishes the amount of ring distortion in an assembly. The O-ring, being pliable but incompressible, operates by distortion to create an interference fit (zero clearance) called "squeeze." The amount of squeeze is usually 10 to 15% of the Durometer hardness, depending on the O-ring material.

When there is a great amount of squeeze, there is more scrubbing and rolling of the O-ring. Under low pressure, the friction is considerable; under high pressure, the O-ring is most distorted and there is a greater tendency for this ring to adhere to the metal surface. Low temperature operation requires more squeeze than would otherwise be necessary, since rubber has a temperature coefficient of expansion some six times that of the metal gland, and friction and hardness of the O-ring material increase as temperature decreases.

When there is not enough squeeze, the seal is less efficient and there is more possibility of leakage, especially at low pressure and low temperature. The slightly lower friction gained by reducing the squeeze is neutralized at high pressure by compression of the O-ring in the end of the groove.

A new O-ring may normally swell as much as 10% when exposed to the fluid and working operation. Allowance is made for this in the design of the O-ring groove. Excessive swelling, however, indicates that the ring and fluid may not be compatible. Excessive swelling of the O-ring seal may increase friction many times beyond the maximum value, weakening the rubber so that it extrudes or sloughs off in components that must remain at very low friction values to function properly.

Sound designs using hard rubber to resist extrusion have been found workable, but hard rubber is easily scarred by sharp particles, and it does not seal as well as the softer materials because it cannot deform to follow surface irregularities.

To take full advantage of its resilience, the O-ring is to move freely in the groove. If the ring is restricted, it may tear as it swells. Freedom of movement is ensured

by the design of the groove, the lubrication of the O-ring, and its ability to return to its original shape.

Only butyl and ethylene propylene (EPR) rubber seals are recommended for use in Skydrol systems, since they are resistant to this fluid. These rings are identified by a green stripe and a color dot, or a green stripe and several colored dots, depending on the manufacturer; however, some manufacturers are no longer marking the seals, but are packaging them in individually sealed and identified wrappings. So that seals do not become mixed or used in improper installations, the package is not to be opened until the seal is ready for installation.

Most O-rings are similar in appearance but their characteristics may vary; that is why it is important to read the package label carefully. A double check is to be made before installing an O-ring to be sure it is the proper part for a particular system.

It should be remembered that the materials from which O-rings are fabricated have been compounded for various operating conditions, temperatures, and fluids. An O-ring will be useless if it is not compatible with the system fluid and operating temperature. A fluid producing very little effect on a seal at room temperature, will noticeably cause swelling of the seal at operating temperatures. Silicone seals will often recover their original properties if allowed to dry out after exposure to the fluid or solvent.

O-rings in service undergo a slight swelling and softening and may be subjected to wear that is not always apparent to the eye; these O-rings are prone to inadvertent damage on reinstallation. It is recommended, therefore, that only new rings be used when reassembling a unit. This can do much to preclude and eliminate difficulties.

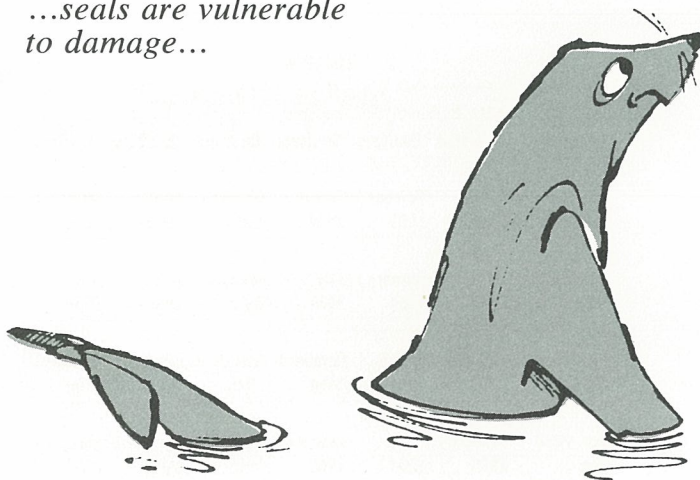
Inspection of the old, damaged O-ring may indicate failure from wear, extrusion, excessive permanent set, torsional strain, or excessive rolling in the groove. Failure from normal wear may be expected, but excessive extrusion may indicate that the O-ring was

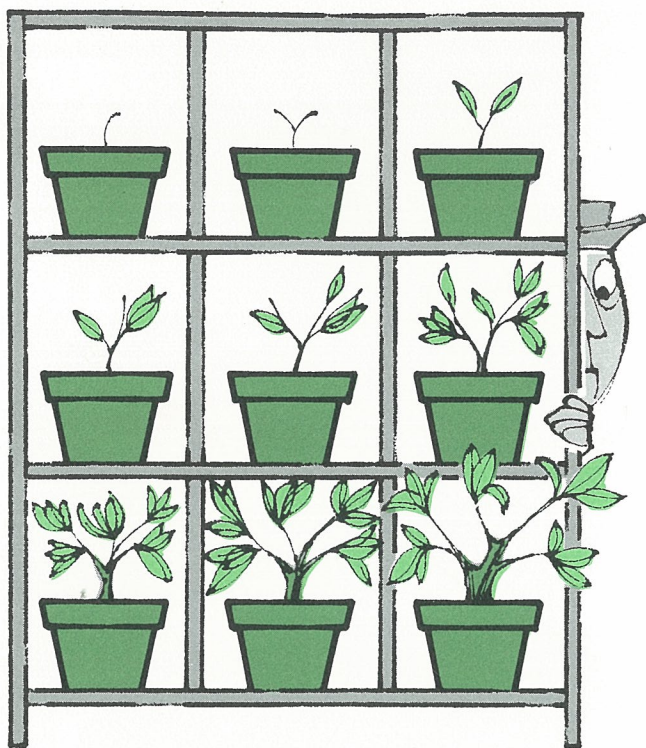
improperly selected for the groove in which it was placed, or that backup rings were not installed when necessary.

If the O-ring lacks proper resilience, it may be that during service it was subjected to temperatures higher than the normal maximum. O-rings are not designed for high temperatures and, whether they have failed or not, they are to be replaced as soon as it is known that they have been exposed to such heat, regardless of their appearance. Characteristically, such overheated rings have a frosty appearance, take a set, and lack resilience; thus, they are not capable of withstanding the effects of friction which they must undergo with each cycle of the system.

A proper O-ring installation generally results in diametral squeeze of approximately 10% of the O-ring cross-section. The volume of the O-ring is also slightly less than the volume of the groove. The initial squeezing is to facilitate a proper seal. The slight "left-over" area in the groove is to accommodate slight normal swelling and to permit a sliding, rolling, and kneading action of the O-ring under pressure and movement. The rolling aids in working fluid under the O-ring to keep it lubricated.

*...seals are vulnerable to damage...*





STORAGE LIMITATIONS

From time of receipt of rubber products at General Dynamics Convair to time of delivery to a customer, surveillance is maintained to assure that the parts listed in the following tabulation, Table III, do not exceed the limits specified in Table IV.

TABLE III

| Part  | Procurement Specification |
|---|---------------------------|
| "O" RINGS—Fuel Resistant.....                                   | MIL-P-5315                |
| GASKETS—Tube Fitting Boss.....                                  | MIL-G-5510                |
| PACKINGS AND GASKETS—Hydraulic.....                             | MIL-P-5516                |
| SYNTHETIC RUBBER—Molded, Extruded and Sheet (class I only)..... | MIL-R-6855                |
| RUBBER—Molded, Extruded, Solid and Sheet.....                   | MIL-R-7362                |
| PACKINGS—Preformed, Hydraulic.....                              | MIL-P-23732               |
| RINGS, PACKINGS—Fuel Resistant 70-80.....                       | AMS-7260                  |
| RINGS, Sealing—Fuel Resistant, 65-75.....                       | AMS-7270                  |
| RINGS, Sealing—Fuel Resistant, 60-70.....                       | AMS-7271                  |
| RINGS, Sealing—Synthetic, Lubricant Resistant, 65-75.....       | AMS-7272                  |
| RINGS, Sealing—Oil Resistant.....                               | AMS-7274                  |
| RINGS, Sealing—Synthetic, Lubricant Resistant.....              | AMS-7275                  |
| HOSE—Low Pressure Flex.....                                     | MIL-H-5593                |
| HOSE—Fuel, Oil, Coolant, Water and Alcohol.....                 | MIL-H-6000                |
| HOSE—Aromatic Fuel, Self Sealing.....                           | MIL-H-7064                |
| HOSE—Flame Resistant.....                                       | MIL-H-7938                |
| HOSE—Hydraulic and Pneumatic.....                               | MIL-H-8788                |
| HOSE—Hydraulic and Pneumatic (3000 psi).....                    | MIL-H-8790                |
| HOSE—Hydraulic, Pneumatic, Fuel, Oil Resistant.....             | MIL-H-8794                |
| HOSE—Hydraulic, Pneumatic, Fuel, Oil Resistant.....             | MIL-H-8795                |

Rubber parts other than those listed should be stored and issued on a "stock rotation" basis—i.e., the oldest stock to be issued first; age limits do not apply.

TABLE IV  
AGE LIMITS

|  | Accumulated Age (Max) |        |
|--|-----------------------|--------|
|  | Quarters              | Months |
| 1. SEALING RINGS, PACKINGS, AND GASKETS:                             |                       |        |
| UNINSTALLED: Time from cure date to:                                 |                       |        |
| (a) Receipt from manufacturer or his agent.....                      | 4                     | 12     |
| (b) Receipt from source other than above.....                        | 6                     | 18     |
| (c) Shipment as spare part.....                                      | 6                     | 18     |
| (d) Installation in components or system.....                        | 8                     | 24     |
| INSTALLED: Time from assembly date to:                               |                       |        |
| (e) Receipt of component, accessory, or engine.....                  | 4                     | 12     |
| (f) Shipment of component, accessory, or engine as spare or kit..... | 6                     | 18     |
| (g) Delivery of aircraft to customer.....                            | 10                    | 30     |
| 2. HOSE AND HOSE ASSEMBLIES: Time from cure date to:                 |                       |        |
| (a) Receipt of bulk hose.....  | 4                     | 12     |
| (b) Receipt of uninstalled hose assemblies.....                      | 6                     | 18     |
| (c) Shipment of uninstalled hose assemblies—spares or kits.....      | 8                     | 24     |
| (d) Shipment of engine with hose installed.....                      | 12                    | 36     |
| (e) Delivery of aircraft with hose installed.....                    | 16                    | 48     |
| NOTE: See TABLE V for method of calculating age.                     |                       |        |

Upon receipt of parts at Convair, information is recorded on a Cure Date Tag. This tag, which accompanies each part, bears the cure (or assembly) date, expiration date for 'spares' use, and expiration date for production use per the age limits shown in Table IV.

Parts held in storage or pending shipment are protected from excess air circulation, weather, and direct sunlight. Temperatures do not exceed 100°F.

Cure dates and component assembly dates are marked by the part manufacturer to indicate quarter of year, and year in which part was cured or component was assembled.

An example of the quarterly date code shown in Table V is as follows:

"1 Q 62" indicates first quarter of 1962. Rubber parts are not considered one quarter old until the end of the quarter succeeding the quarter in which the part was cured.

Cure dates of uninstalled parts are marked by the parts manufacturer on the part containers. When a lot is separated, the cure date on the initial lot container is transferred to each split lot container.

TABLE V

| Date on Part or Component | Age in Quarters on Dates Shown |                |                |                |                |                |
|---------------------------|--------------------------------|----------------|----------------|----------------|----------------|----------------|
|                           | 4 Quarters                     | 6 Quarters     | 8 Quarters     | 10 Quarters    | 12 Quarters    | 16 Quarters    |
| Jan.                      |                                |                |                |                |                |                |
| Feb. 1Q62                 | April 1 1963                   | October 1 1963 | April 1 1964   | October 1 1964 | April 1 1965   | April 1 1966   |
| Mar.                      |                                |                |                |                |                |                |
| Apr.                      |                                |                |                |                |                |                |
| May 2Q62                  | July 1 1963                    | January 1 1964 | July 1 1964    | January 1 1965 | July 1 1965    | July 1 1966    |
| June                      |                                |                |                |                |                |                |
| July                      |                                |                |                |                |                |                |
| Aug. 3Q62                 | October 1 1963                 | April 1 1964   | October 1 1964 | April 1 1965   | October 1 1965 | October 1 1966 |
| Sept.                     |                                |                |                |                |                |                |
| Oct.                      |                                |                |                |                |                |                |
| Nov. 4Q62                 | January 1 1964                 | July 1 1964    | January 1 1965 | July 1 1965    | January 1 1966 | January 1 1967 |
| Dec.                      |                                |                |                |                |                |                |



Following is a listing of some of the rubber parts found on Convair aircraft.

| APPLICATION                                       | DESCRIPTION  |
|---|--|
| Horizontal and vertical stabilizer balance boards | Tricot weave Dacron impregnated and molded to a thin layer of silicone rubber over a core of silicone foam rubber. Seal is designed to withstand 15,000 to 20,000 cycles of adaptor pin through 41° of arc before replacement. Seal is designed to remain flexible at a temperature range of -65° to +180°F. |

| APPLICATION  | DESCRIPTION   |
|--|---|
| Self-energizing bulb-diaphragm seal for cargo doors; hydraulic compt, and electronics/electrical compartment doors | Self-energizing bulb diaphragm seal of silicone rubber with Dacron reinforcement at splice on inside surface of seal. Seal is designed for 8.4 psi operating pressure and for temperatures of -65° to 150°F without taking permanent set. Pressure is induced through 0.06" holes at 8-inch spacing on inboard side. Seal is resistant to deterioration due to aging.   |
| Forward and aft entrance doors   | Flex support seal of Hi-Tear silicone elastomer, reinforced with Dacron. Outer pressure bag of calendered silicone, reinforced with heavy open weave Dacron with major stress axis across the seal to increase stretch in crown area. Inner pressure bag of calendered silicone with lightweight open weave Dacron. Seal has sponge tube core padding across top and at all four corners, extending 3 inches beyond corner tangency points. The seal is designed for a temperature range of -65° to 150°F without taking permanent set. |
| Emergency exit door seal   | Molded silicone rubber (Shore 40A) with section of closed cell silicone sponge, covered with silicone rubber cloth. Seal is designed to remain flexible at temperature range of -65° to 150°F, and will not deteriorate or swell greater than 15% when subjected to occasional splash or drip of Skydrol 500.   |
| Leading edge seal  | Silicone rubber seal (Shore 50A) conforming to AMS3345. Seal is designed for a temperature range of -100° to 400°F; it is resistant to Skydrol 500.   |
| Aileron and aileron trim tab curtain   | Curtain and reinforcing strips of butyl-impregnated Dupont nylon.   |
| Outboard flap carriage slot seal   | Curtain, facings, welt and reinforcing strips of butyl-impregnated nylon, plus Stanflex Fab 300, a neoprene-coated nylon fabric.  |
| Buffet water connection seal   | Chloroprene (neoprene) weather-resistant seal (AMS3207), providing low loss in tensile and elongation after aging at 212°F.   |
| Lavatory counter seal  | Flexible vinyl extrusion with Shore hardness of 70-90.  |
| Lavatory counter bumper  | 1/8-inch sheet, type 3, grade A weather-resistant chloroprene (AMS3208); low loss in tensile and elongation after aging to 212°F.   |
| Lavatory counter seal  | 1/32-inch synthetic sheet (AMS3204); low temperature resistance to -70°F.   |
| Anti-shock bumper  | Silicone reinforced with tricot open-weave Dacron polyester with fiberglass-laminated base. Bumper is designed to compress 15% ± 5 of original thickness under a stress of 75 psi, with resultant permanent set at 2% maximum at temperature range of -65° to +180°F. Resistant to Skydrol and JP4 fuel.  |
| Wing leading edge seal   | Molded fluorosilicone rubber, Grade 50. Outer cover of plain weave bias-cut Dacron, 0.007 thick. Ends of seal are sealed with fluorosilicone sponge rubber. Temperature range -65° to +180°F.   |
| Leading edge wing flap seal  | Silicone rubber (Shore 70A) reinforced with Dacron. Compounded for flexibility at temperatures of -65° to +350°F.   |

| APPLICATION                             | DESCRIPTION  |
|---|--|
| Elevator and rudder balance board seals | Skydrol-resistant silicone rubber, Dacron-wrapped and bonded with fiberglass cloth. Temperature range of -65° to +180°F. Seal is designed to remain flexible without taking permanent set.   |
| Carpet pad installation                 | Flexible Stafoam, Type D, 0.25 thick. Flexible urethane foam of uniform cells with a firm structure. Will recover original thickness after deflections of 50 to 75%. Remains flexible at temperatures to -80°F, but increasing stiffness as temperature falls below -10°F. Will melt at temperatures of 500°F, but may be exposed to 250°F for extended periods; to 400°F for shorter periods. Immune to common dry cleaning solvents. Chlorobenzene, carbon tet, ethyl acetate and acetone cause swelling, but these effects disappear with drying. Available in densities from 1.5 to 80 lb/cu ft. |
| Aft entry upper panel assembly          | Spongex medium grade M-407, 4 ± 1 lb/cu ft.; natural or man-made rubber chemically blown to yield uniform structure of interconnecting cells. Resistant to oils, acids, and corrosive vapors.  |
| Cabin wainscot trim seal                | Stafoam (latex) with excellent thermal and sound insulation properties; temperature range -65° to 200°F.   |
| Instrument junction box curtain         | Silicone-impregnated fiberglass.   |
| Flight deck window insulation           | Polyurethane foam F-29, 4 lb/cu ft. density, Nitron 376 cover.   |
| Buffet and lavatory hose installation   | Rubber-impregnated fiberglass cloth. Noiseless under vibration, fire resistant, resistant to most vapors and liquids, flexible and serviceable at temperatures of -65° to 450°F.   |
| Bulkhead bellows seal                   | Fume-tight silicone rubber-impregnated fiberglass bellows seal end is flexible, soft, and expandable to 5.25 I.D., seal leakage not to exceed 0.5 cfm standard air at 5 psig internal pressure.  |
| Cabin air supply ducting                | Flexible coupling section of neoprene-impregnated nylon; temperature limits -65° to +200°F.<br>Asbestos and synthetic rubber sheet, hot-oil resistant, Shore 80, between mounting clip and duct.   |
| Buffet air supply flexible coupling     | Nylon material impregnated with neoprene, both sides.  |
| Air conditioning underwing coupling     | Neoprene-impregnated laminated fiberglass; flexible enough to stretch 0.25 above given diameter.   |
| Spoiler stop seal                       | Silicone with outer cover of plain-weave Dacron. Core and cover integrally molded; 0.30 lb/cu ft; not to swell greater than 15% when immersed in Skydrol 500 for 168 hours at temperatures of -65° to 180°F.   |
| Wing-to-pylon fuel line seals           | Resistant to turbine fuels and aviation gasoline—zero leakage at -65° to 160°F.  |
| NLG door seal                           | Silicone rubber; does not take permanent set; flexible at -65° to 180°F. Will not deteriorate in Skydrol or swell greater than 15% for 150 hours at noted temperatures.  |

# GLOSSARY OF RUBBER TERMINOLOGY



**AGING**—Natural deterioration by oxygen, ozone, heat, and light.

**ANILINE POINT OF OIL**—Lowest temperature at which equal volumes of freshly distilled aniline and a particular oil which is being tested are completely miscible.

**ANTIOXIDANTS**—Substances that retard oxidation.

**ANTIOZONANTS**—Substances that retard or prevent cracking from exposure to tension and to ozone.

**ANTIRAD**—Material that inhibits radiation damage.

**BURST STRENGTH**—Ability of a rubber to resist rupture by pressure.

**COLD FLOW**—An elastic material's change from its original shape when subjected to pressure for a sufficient period of time.

**COMPRESSION SET**—Permanent deformation resulting from compressive forces on a section of rubber.

**CELLULAR RUBBER**—Sponge rubber.

**DUROMETER**—Common measure of rubber hardness such as resistance to indentation. Also, scale used to measure hardness, calibration from 0 (very soft) to 100 (very hard).

**ELASTICITY**—The property of a material which causes it to resist deformation and thereby to recover its original shape and size once the deforming force is removed.

**ELASTOMER**—A material that will return to its original dimension after being stretched or distorted.

**ELONGATION**—The per cent of extension of a rubber part over its original shape before breaking.

**FLEX CRACKING**—The formation of cracks on the surface of rubber parts due to repeated bending or flexing.

**FLEX LIFE**—The length of time before an elastomer will weaken and break down because of continuous bending.

**FRICTION (Breakout)**—The initial friction developed when a packing is employed as a moving seal.

**FRICTION (Running)**—The constant friction developed during the use of a packing as a moving seal.

**HARDNESS (Durometer)**—Amount of resistance of rubber to indentation; its numerical value will differ

according to the apparatus and method used in the determination. For simplicity, it is usually specified by Shore Durometer.

**MODULUS**—The force in pounds necessary to stretch a piece of rubber one square inch in cross-section of a specified amount. It is the measure of resistance to extension. A high modulus stock is a stiff stock.

**OZONE CRACKING**—Cracks on surface of stressed rubber caused by ozone in atmosphere or in test chamber.

**PERMANENT SET**—Lack of ability of rubber to return to its original shape after it has been subjected for a period of time to either stress or strain.

**PLASTICITY**—The condition of pliability which enables a material to be easily formed, molded, extruded, or sheeted.

**PLASTICIZER**—An ingredient applied to a rubber to soften or otherwise modify its properties.

**RESILIENCE**—Energy of a rubber to recover from distortion.

**REVERSION**—Softening of rubber when heated, particularly in a confined place.

**TACK**—The amount of stickiness on the surface of rubbers which enables them to be bonded. Some synthetics are lacking in tack and must be specially compounded to increase this quality.

**TEAR RESISTANCE**—The amount of resistance of rubber to the growth of a cut or tear after tension is applied.

**TEMPERATURE RANGE**—The lowest temperature at which a rubber stays flexible, and the highest temperature at which a rubber will perform satisfactorily.

**TENSILE STRENGTH**—The resistance of rubber to rupture under tension. It is usually expressed in pounds per square inch at break.

**THERMOSETTING MATERIAL**—A substance that hardens or becomes permanently rigid when heated.

**TORSIONAL STRENGTH**—The ability of a rubber to withstand torque.

# U.S. Coast Guard to use Telemetering Buoy System

The U.S. Coast Guard will soon replace their Scotland Lightship off Sandy Hook, N.J., with a 40-foot diameter, 50-ton buoy developed by General Dynamics Convair and sponsored by the U.S. Navy Office of Naval Research. The disc-shaped buoy is a stable unit topped by a 40-foot superstructure that supports aids to navigation equipment.

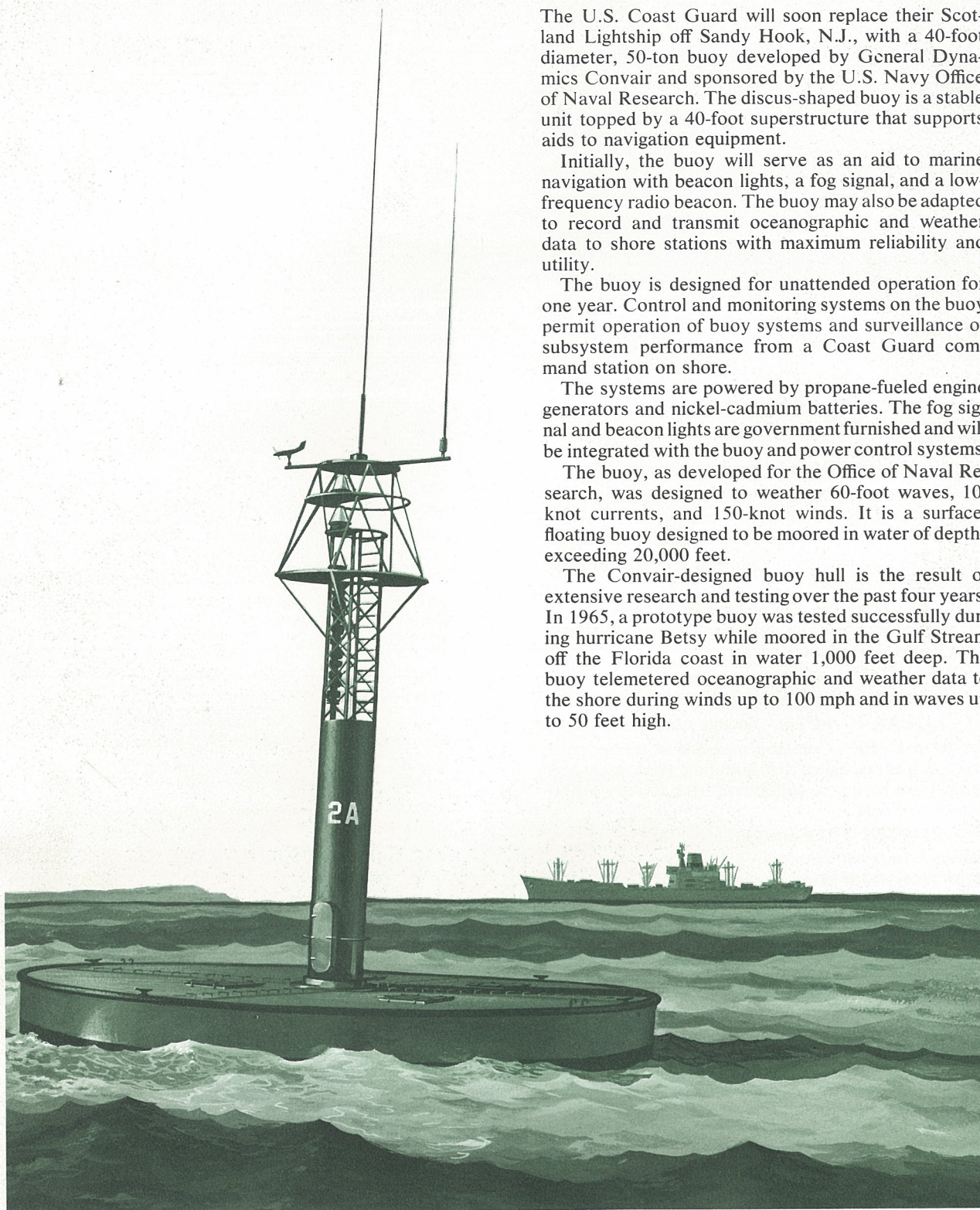
Initially, the buoy will serve as an aid to marine navigation with beacon lights, a fog signal, and a low-frequency radio beacon. The buoy may also be adapted to record and transmit oceanographic and weather data to shore stations with maximum reliability and utility.

The buoy is designed for unattended operation for one year. Control and monitoring systems on the buoy permit operation of buoy systems and surveillance of subsystem performance from a Coast Guard command station on shore.

The systems are powered by propane-fueled engine generators and nickel-cadmium batteries. The fog signal and beacon lights are government furnished and will be integrated with the buoy and power control systems.

The buoy, as developed for the Office of Naval Research, was designed to weather 60-foot waves, 10-knot currents, and 150-knot winds. It is a surface-floating buoy designed to be moored in water of depths exceeding 20,000 feet.

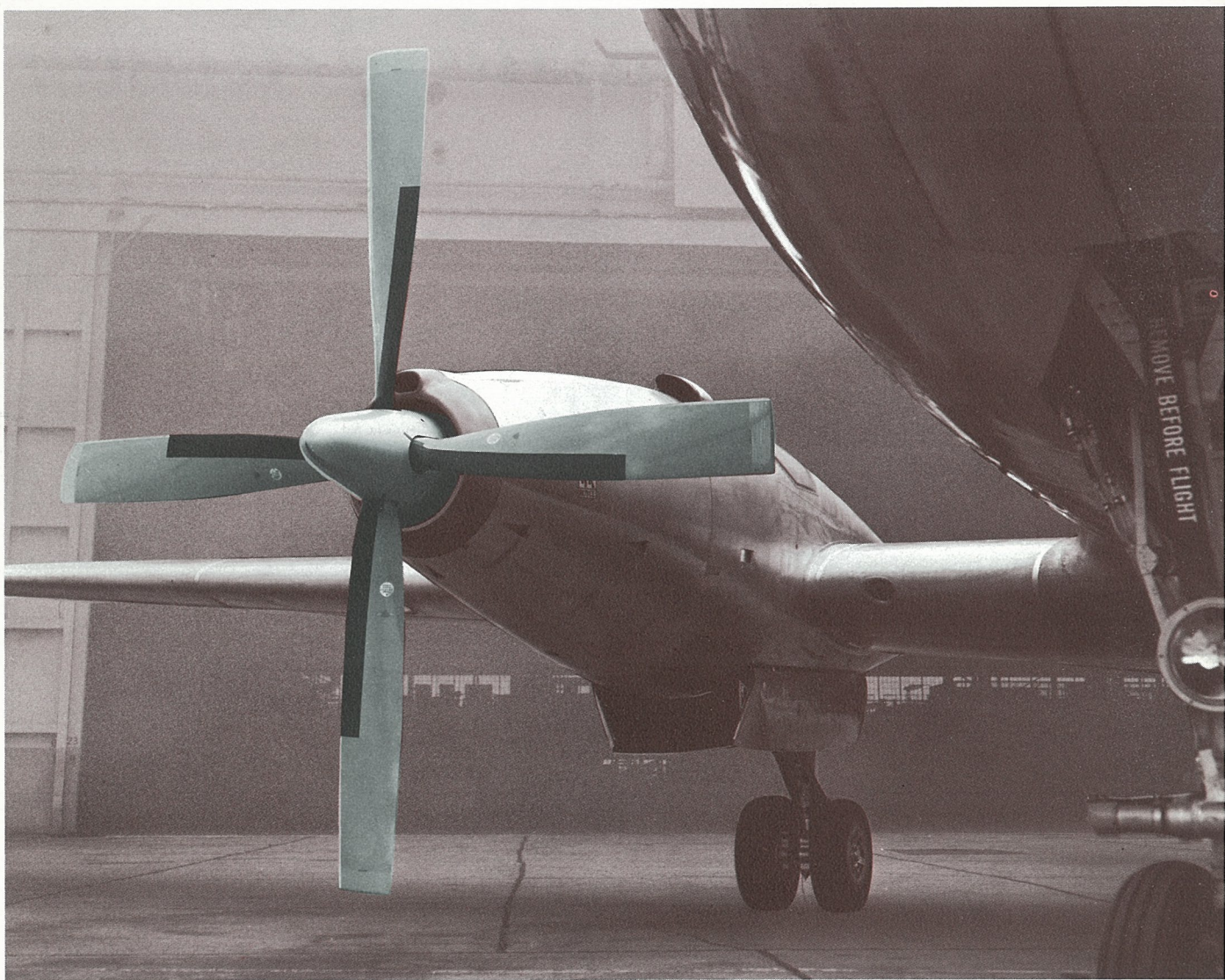
The Convair-designed buoy hull is the result of extensive research and testing over the past four years. In 1965, a prototype buoy was tested successfully during hurricane Betsy while moored in the Gulf Stream off the Florida coast in water 1,000 feet deep. The buoy telemetered oceanographic and weather data to the shore during winds up to 100 mph and in waves up to 50 feet high.



**GENERAL DYNAMICS**  
*Convair Division*

VOLUME XVIII    NUMBER 3    SEPTEMBER/OCTOBER 1966

# *Convair Traveler*



*In This Issue: The Dowty Rotol Propeller  
Loss of Directional Control*

VOLUME XVIII NUMBER 3 SEPTEMBER/OCTOBER 1966

## Convair *Traveler*



In This Issue: The Dowty Rotol Propeller  
Loss of Directional Control

### OUR COVER

The Dowty Rotol propeller, used with the Rolls-Royce R. da. 10 engine on Convair 600/640 aircraft, has four square-tipped blades. This article, illustrated by Bob Sherman, describes the various propeller operating systems, from engine starting to approach and touchdown. Harvey Adams illustrated the article on Loss of Directional Control.

# Convair *Traveler*

VOLUME XVIII NUMBER 3 SEPTEMBER/OCTOBER 1966

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FROM PROPS TO TURBOPROPS

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## The Dowty Rotal Propeller

THE PROPELLER used with the Rolls-Royce Dart engine on the Convair 600/640 is a Dowty Rotal four-bladed, variable pitch unit that is hydraulically operated and electrically controlled. Diameter of the propeller is 13 feet, providing a ground clearance of 14.9 inches and a fuselage clearance of 25 inches.

The blades are of solid dural with square tips. The leading edge of the blade is machined on both the pitch and camber faces, forming a recess for approximately two thirds of the blade length from the hub to accommodate a rubber shoe which contains heating elements. The deicing overshoe forms a flush surface with the airfoil section of the blade to maintain aerodynamic efficiency. Similar heaters are fitted to the interior of the light alloy nose spinner which encloses the propeller hub and pitch change mechanisms.

The propeller is driven from the engine reduction

gear which transmits torque to a rotating annulus gear on the propeller shaft. Propeller gear ratio is 0.0775 times engine speed.

Blade angle is changed by a main piston which turns the blades through interconnecting links attached to the blade roots. Blade angle pitch range is variable and is limited by fixed abutment type stops from 0° (ground fine) to 84° (full feather). The ground fine pitch position enables engine starting to be carried out with minimum propeller load being applied to the turbine blades. Safety factors designed into the system prevent the propeller from reaching ground fine position in flight in event of governor malfunctions.

Dual purpose controls on the pedestal (figure 1) provide for operation and control of blade angle and fuel flow for starting, idling, takeoff, and landing. Auto-

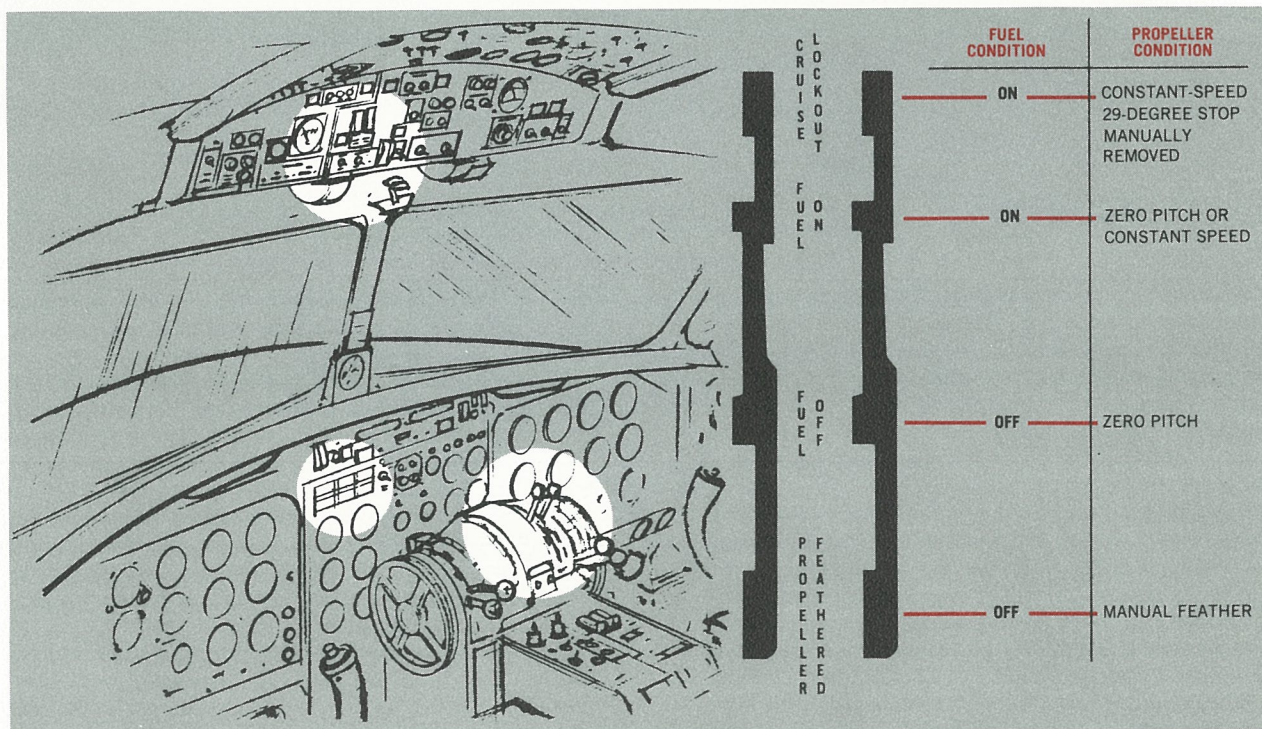


Figure 1. View showing condition levers on pedestal and location of warning lights.

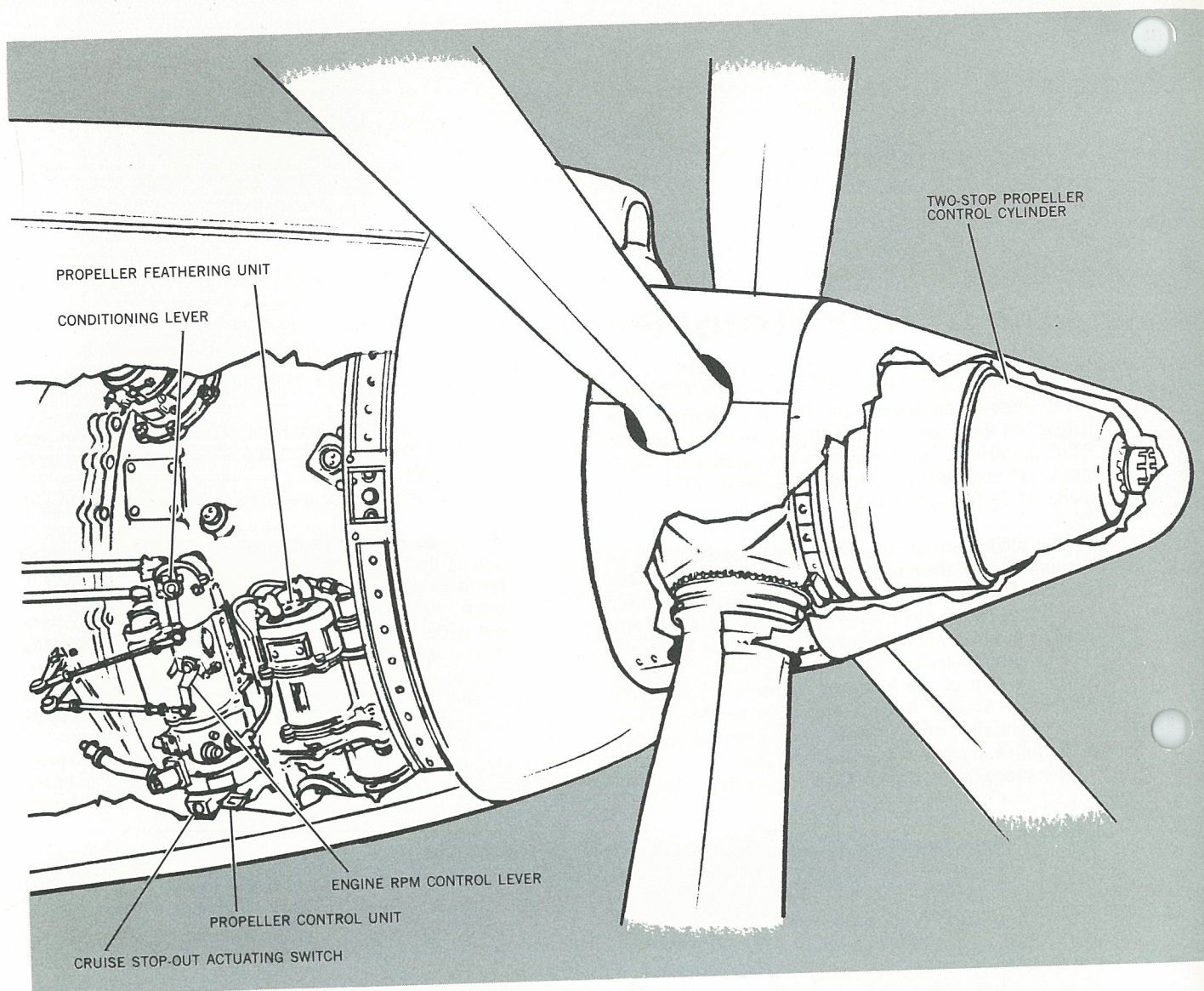


Figure 2. Detail showing typical propeller operating systems.

feathering, manual feathering, autocoarsening, and propeller synchronizing systems are also incorporated. Continuous indication of propeller operation and warning of malfunction are provided by eight warning lights (figure 1). Six dual lights are located on the engine instrument panel, and two single lights on the pilots' overhead switch panel. These will be covered in detail later in this discussion.

The governor unit on the variable pitch propeller is interconnected with the throttle lever to give single lever control of engine power. To maintain the correct air/fuel ratio required by the Dart engine for any given throttle valve setting at ISA sea level conditions, there is a uniform corresponding selected engine speed that determines the combustion air flow.

The condition lever is interconnected with the high-pressure cock of the engine fuel control unit, to turn fuel on and off, and with the manual feathering con-

trol of the propeller control unit. It also operates switches in the autofeathering and manual feathering circuits.

The propeller control unit (PCU), one mounted on each engine, is linked to the engine fuel control and the pilot's throttle lever in such a way that, during normal operation, there is only one rpm selectable for a given fuel flow above 11,800-rpm.

The minimum selected rpm is limited to a value that maintains a relatively high rpm on approach, even when fuel is reduced to a low value. This permits a rapid thrust response to throttle movement in the event of an aborted landing.

Substantial braking drag is provided after touchdown without the necessity of reverse thrust. This requires throttle at idle and removal of Flight Fine Pitch stops at touchdown. RPM is well below governor rpm.

The propeller control unit contains three solenoids which operate hydraulic valves. The first of these, the Flight Fine Pitch Stop solenoid, admits pressure oil into the third oil line to remove a mechanical stop in the propeller cylinder. The second, the Pitch Coarsening solenoid, causes the blades to be driven towards a coarser pitch (toward feather), for as long as current is supplied to its coil, and pressure oil is available. The third, the Cruise Pitch Stop solenoid, when energized, causes pressure oil to be admitted to the Fine Pitch pressure relief valve, which in turn controls a mechanical stop in the propeller cylinder. A solenoid isolating valve, operated by the engine condition lever, bypasses electrical requirements for removal of the Cruise stops and is used for manual feathering.

Also incorporated in the PCU is a pressure-sensitive switch, which operates when pressure in the third oil line exceeds approximately 25 psi. Purpose of this switch is to operate an indicator light (CRUISE STOP OUT) in the cockpit to show the effectiveness of the cruise pitch stop in the propeller cylinder (figure 3).

To better understand the functioning of the control systems, a description of the various stops and other safety devices are discussed in their sequence.

The Hub Switch at 17° is a cam-operated switch mounted on the rear of the propeller hub and is set to be closed over the blade angle range from ground fine

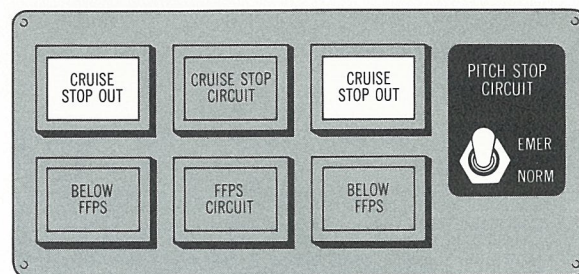


Figure 3. The amber Cruise Stop Out light is ON, when oil pressure operates PCU Lock indicator; when annulus venting drain is blocked; or when flight fine relief valve operates.

(0°) to 17°. This switch prevents the blade angle from falling below 17° in the event of failure of the mechanical Flight Fine Pitch stop, by energizing the Pitch Coarsening solenoid.

The Pitch Coarsening circuit through the 17° hub switch is inoperative when the 19° stops are withdrawn. This provision is necessary so that low pitch angles, required for starting windmill braking and ground running, may be obtained.

The 17-degree switch also operates a Below Flight Fine Pitch Stop (BELOW FFPS) light in the cockpit

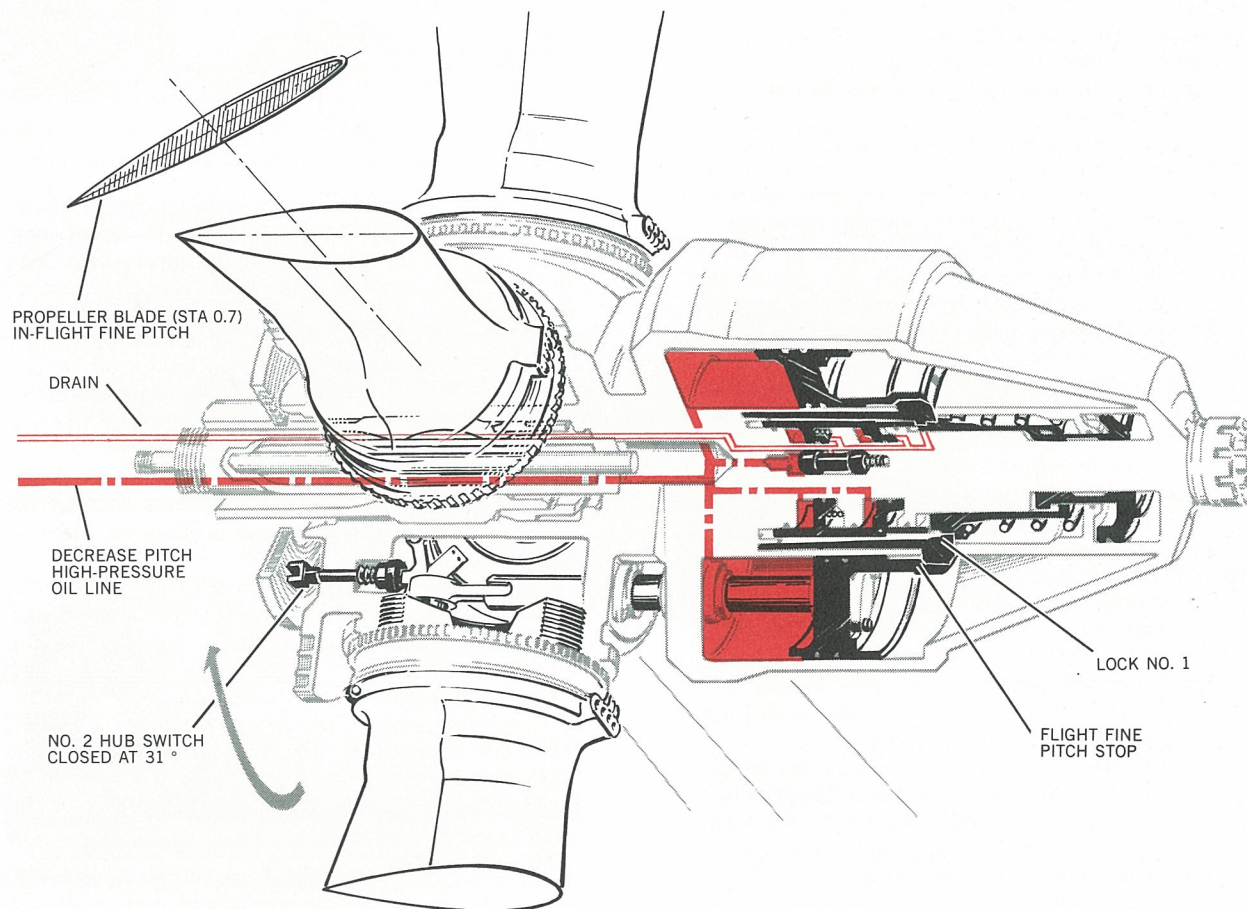


Figure 4. Propeller operating piston in Flight Fine Pitch position.

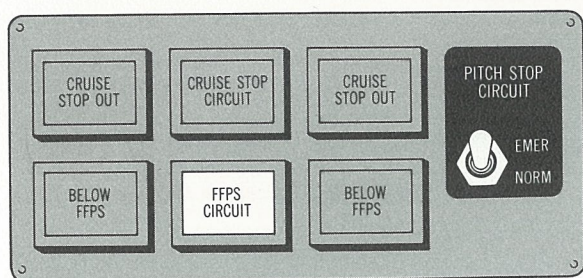


Figure 5. The amber FFPS Circuit light is ON when either or both power levers are below 13,000 rpm and throttle T handle is pulled, or when Gust Lock is engaged and either or both power levers are below 13,000 rpm.

(one for each propeller) to show that the blades have passed through the mechanical Flight Fine Pitch Stop and have entered the low-pitch range.

The mechanical *Flight Fine Pitch Stop* (FFPS) prevents overspeed of the engine when the propeller blade angle is below cruise, such as in takeoff, approach, and in certain climb segments, if a malfunction should occur. The 19-degree angle is less than that required to absorb full power under all climatic conditions with the aircraft static, thus ensuring that the stop does not interfere with constant speeding operation. The stop also prevents the propellers from going into zero pitch until it is required for braking after touchdown. Should the governor fail, withdrawal of the stops requires two separate and distinct operations by the pilot; thus inadvertent withdrawal is unlikely (see figure 4).

The FFPS solenoid must be energized by pilot selection immediately after touchdown so that advantage can be taken to windmill braking after landing, and to avoid the possibility of overheating the engines. The pilot will effect withdrawal of the stops in both propellers by pulling throttles to idle and then lifting and pulling the throttle lock handle aft to operate two switches which energize the pitch stop withdrawal circuits.

An amber FFPS CIRCUIT light on the engine instrument panel indicates that the stops withdrawal circuit is armed; this guards against the possibility of the stops being withdrawn inadvertently or in danger of being energized through some failure while the aircraft is in the air (see figure 5).

The FFPS CIRCUIT light should always be illuminated when the aircraft is on the ground, except when the throttles on both engines are advanced beyond 13,000 rpm. The light will be out, if the pilot forgot to release the Flight Fine Pitch Stops by pulling on the throttle lock handle at touchdown; engine overheating will result. The light will not illuminate if the Pitch Stop Circuit switch is in the EMER position.

A parallel electrical lock-in circuit for the Flight Fine Pitch Stop removal is designed to operate through motion of the gust lock handle. This prevents inadvertent propeller autocoursening and engine overheating during engine starting and taxiing.

A propeller *Below Flight Fine Pitch Stop* (BELOW FFPS) indicator for each propeller will illuminate when the respective propeller blade angle is at 17° or below.

Since the propeller blade must pass the 19-degree mechanical stop to reach 17°, the BELOW FFPS light will give positive indication that the 19-degree stops have been removed (see figure 6).

The mechanical Cruise Pitch Stop is set at a blade pitch angle of 29°. Normally, the stop can be removed only when the cruise pitch stop solenoid in the controller unit is energized, or if the conditioning lever is in CRUISE LOCKOUT. Two cruise pitch stop relays require operation of a 30-degree hub switch on each propeller. The cruise pitch stop solenoids are energized when the blade angle on both propellers is at or below 31°, or when the blades are feathered. Switches at 84° are in parallel with the 31-degree hub switches.

One cruise stop removal switch on the No. 2 blade is set to close at 31°; the other on the No. 4 blade is set to close at 84° to permit stop removal of the operating propeller when one engine is feathered. The cams are set to open the No. 2 switch slightly above cruising pitch angle, and to keep the switch closed at all finer pitch angles. These hub switches are associated

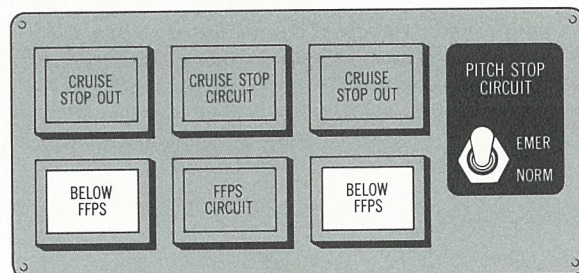


Figure 6. The red Below FFPS light is ON when the 17-degree hub switch is closed for that propeller.

with similar hub switches on the other propeller; therefore, if one propeller "fines off" to the 31-degree angle before the other, it is held at the mechanical latch cruising pitch stop until the other propeller reaches the 31-degree angle, at which time the aircraft circuit is completed and the cruising pitch stop withdrawal solenoids for both propellers are energized. If one power plant is shut down, automatic operation of the cruising pitch stops on the other propeller will still be possible.

There are separate amber CRUISE STOP OUT lights on the engine instrument panel to show whether the 29-degree stop in each propeller is effective. There is

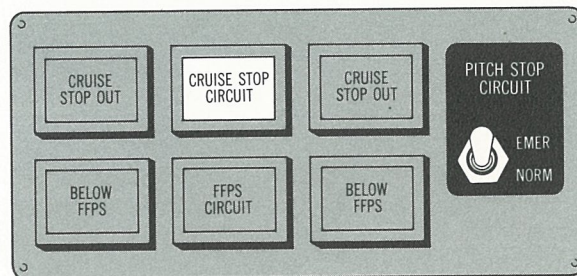


Figure 7. The blue Cruise Stop Circuit light is ON when either or both 31-degree hub switches are closed, or when either or both 84-degree hub switches are closed.

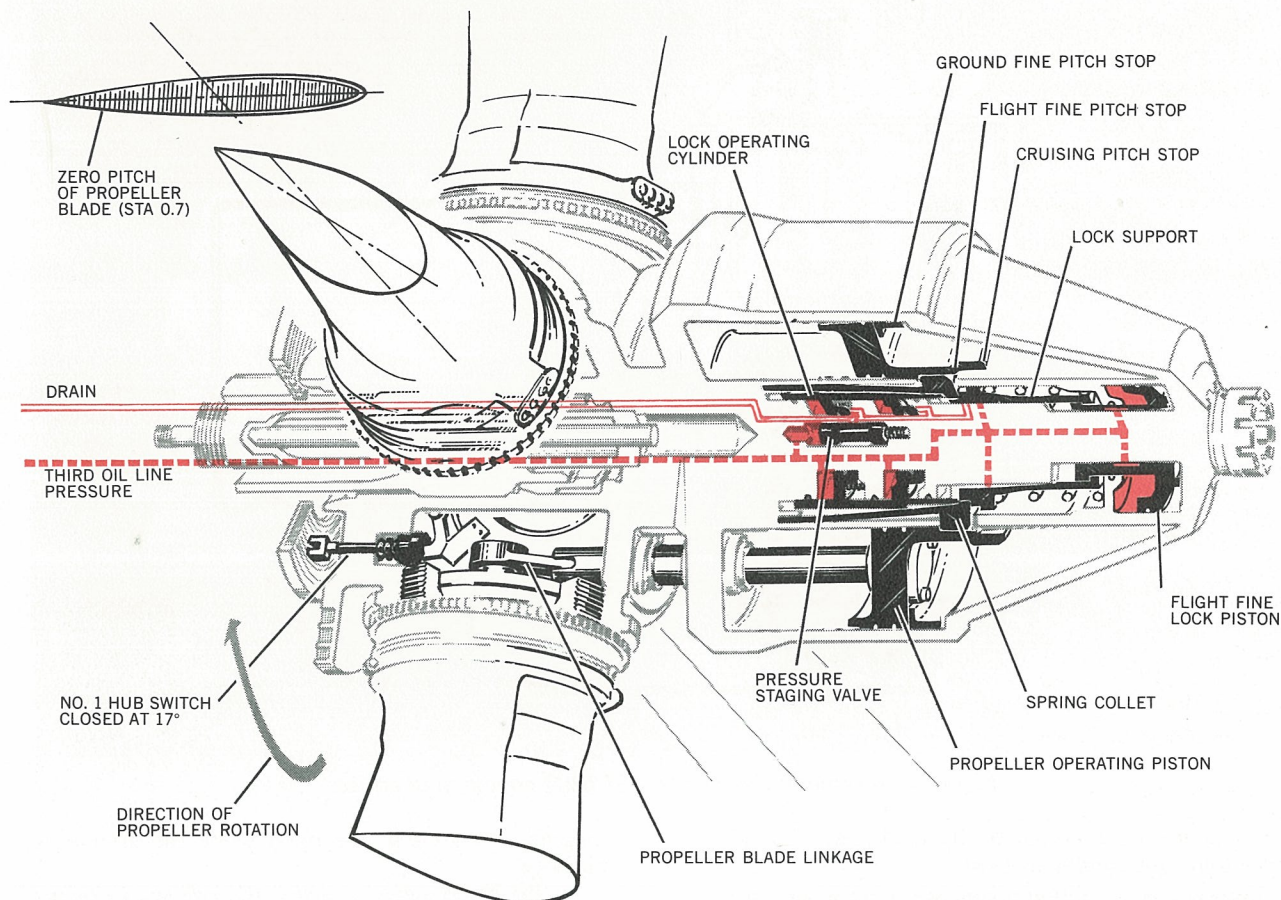


Figure 8. Propeller operating piston shown in Ground Fine Pitch position.

a blue CRUISE STOP CIRCUIT light (figure 7) that illuminates when either or both propellers are at a blade angle of  $31^\circ$  or less, and when either or both propellers are in Feather position. The light does not illuminate if the PITCH STOP CIRCUIT switch is in EMER position.

These lights are operated by the pressure-sensitive switch in the controller unit, which senses third oil line pressure.

The PITCH STOP CIRCUIT switch will deactivate all automatic electrical stop removal circuits and turn off the CRUISE STOP CIRCUIT and FLIGHT FINE PITCH CIRCUIT lights if they were illuminated.

The *Ground Fine Pitch Stop* is a positive abutment type stop set at a blade angle of  $0^\circ$ . This angle corresponds to the limit of travel of the main operating piston towards fine pitch (figure 8).

Feathering may be initiated by the pilot or, in the case of loss of engine power, an automatic system is triggered by the low torque switch on the engine to operate the feathering system.

The propeller feathering unit consists of a gear type oil pump, an electric motor, and purolator filter. For feathering, autofeathering, and unfeather operation, a separate electrically driven pump supplements the PCU pump (see figures 9 & 10).

The autofeathering system is armed at all times on each propeller except when its engine power lever is below 12,800 rpm quadrant position, or the opposite propeller is already feathered or in the process of being feathered. Whenever torque oil pressure recovers and goes above 50 psi before full feather is completed, engine and propeller operations revert to normal.

To feather the propeller automatically or manually, two requirements must be satisfied: oil must be ported to the correct side of the propeller operating piston to force the blades toward increase pitch; and sufficient pressure oil must be supplied to carry the blades all the way to feather (figure 9).

In the event of engine failure, the propeller is automatically feathered by the torque-sensitive coarsening system. The engine torque switch, incorporated in the autofeather circuit, closes if engine oil pressure falls below a minimum value. Completion of the autofeather circuit also brings the feathering pump into operation. After the blades have reached Feather, movement of the condition lever to FEATHER stops the feathering pump motor and opens a switch in the Feather circuit of the opposite engine to ensure that the working engine cannot be automatically feathered by its engine torque switch.

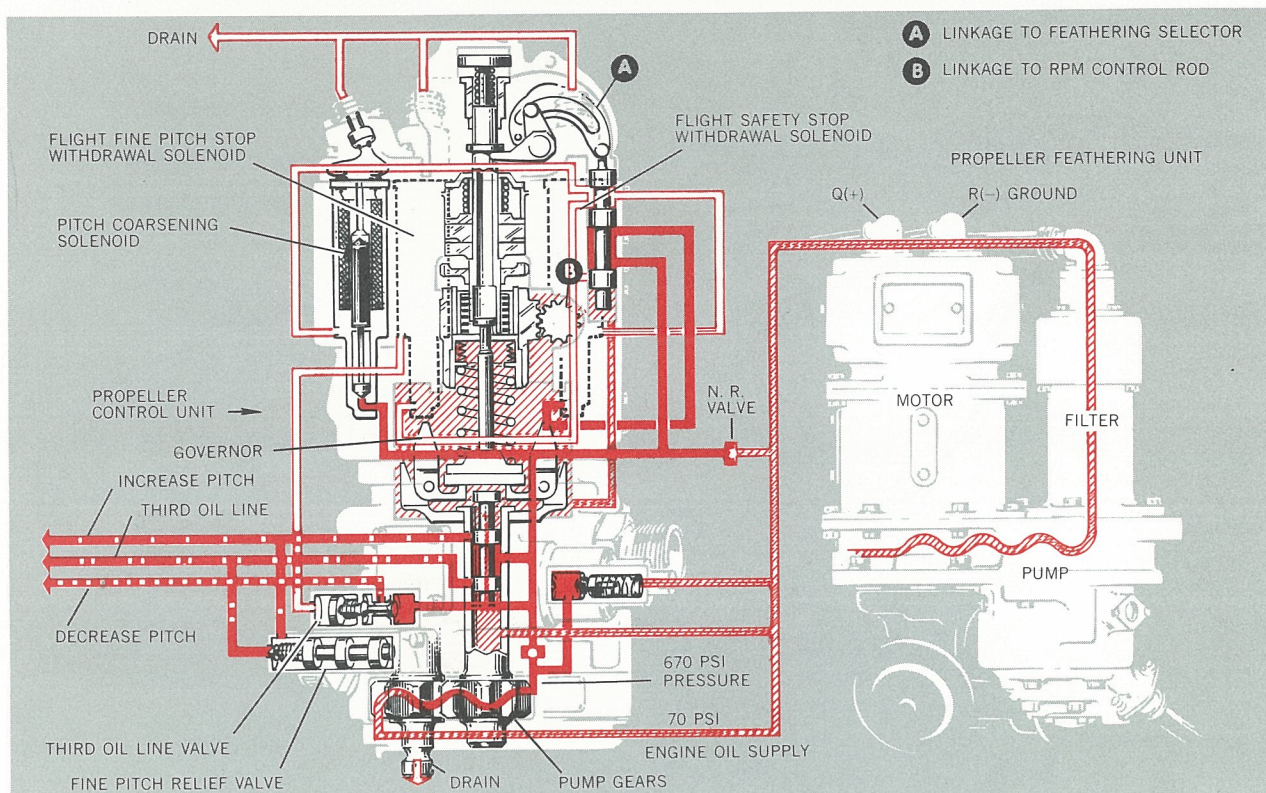


Figure 9. Schematic showing ON-SPEED condition in cruise.

The propeller is automatically feathered when all of the following conditions exist:

Both engine condition levers are in an engine run position (FUEL ON or CRUISE LOCKOUT).

Engine throttle lever is placed above the 12,800 rpm position.

Opposite engine propeller is not in the process of autofeathering.

Power loss on the failed engine is sustained so that its torque pressure drops and stays below 50 psi until the feather cycle is completed.

Under manual feathering conditions, the propeller is feathered by oil from the controller pump and by the feathering pump when this feathering pump is brought into operation by manual operation of the Feather/-Unfeather switch. The toggle type switch is manually held in the Feather position until the propeller is feathered. When the switch is released, spring action returns it to the OFF position to stop the feathering pump motor. The feathered propeller will continue to rotate slowly in the normal direction.

*The feathering pump motor has a limited rating and switch operation is to be limited to three minutes.*

A feather pump light on the overhead switch panel is illuminated whenever its respective feather pump relay contactor is closed (figure 11).

Autocoarsening takes place in the event of propeller control malfunction. The autocoarsening circuit is set to come into operation when the propeller blades reach an angle of 17°, thus preventing the blades from

moving into ground fine pitch while the aircraft is airborne.

As the blade angles coarsen, the hub switch opens and breaks the circuit to the pitch coarsening solenoid. Should the propeller piston not latch over the spring collet as the blades coarsen, autocoarsening sequence of operations will recommence as the propeller blades again "fine off", and the BELOW FFPS light will illuminate during each autocoarsening operation.

Both engines are equipped with a propeller synchronizer alternator; the left engine has a corrector motor. A difference in speed between the slave alternator and the master alternator is signalled to the corrector motor, which adjusts power and rpm until the alternators are synchronized.

Each alternator is mounted on its respective engine gearbox; the corrector motor is mounted in the left-hand nacelle and is connected to the throttle lever linkage. The right-hand engine is the master engine, the left-hand is the slave. An engine synchronizer switch is located on the pilots' overhead switch panel on some versions, and on the pilots' pedestal in others (figure 12).

When placed in the ON position, the engine synchronizer switch completes the circuit to the corrector motor. The corrector motor compares the output of each synchronizer alternator and adjusts the left-hand engine throttle linkage to the engine to compensate for differences between the two engine rpms. A friction device, which is part of the throttle linkage on the pedestal, ensures that motion of the corrector motor is transmitted forward to the engine.

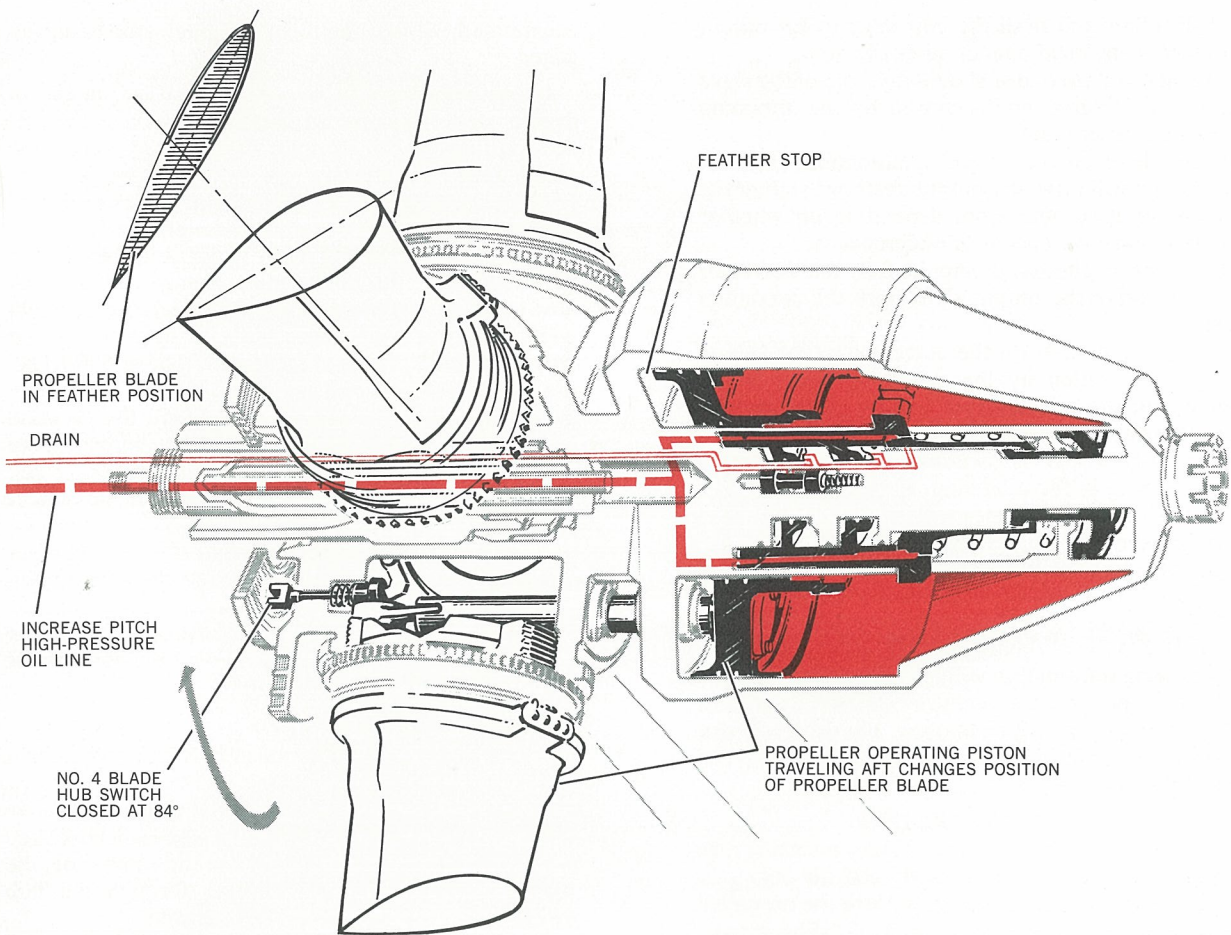


Figure 10. Propeller operating piston shown in Full Feather position.



Figure 11. Amber feather pump lights on overhead switch panel.

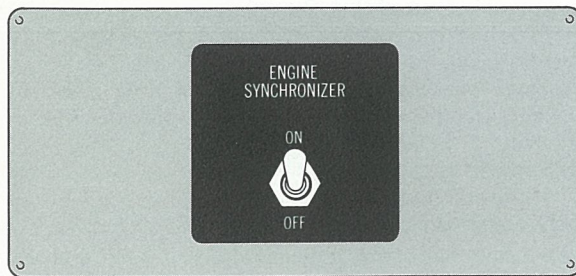


Figure 12. Engine synchronizer switch.

In case of failure of the master (right hand) engine, the left-hand engine may be slowed to a maximum of 350 rpm from datum (neutral). It cannot be further decreased since this is the limit of travel of the corrector motor ( $\pm 350$  rpm from datum).

The engine synchronizer switch is springloaded to the OFF position and, when selected to ON position, is magnetically held there by a circuit which is completed by the main landing gear handle in the UP position. With the main landing gear handle in the DOWN position, the system automatically releases to OFF.

When the synchronizer switch is placed to OFF position to deactivate the system, the corrector motor automatically returns to its datum position so that, when the system is reengaged, full correction in both directions is available.

The engine synchronizer system must be off during takeoff and landing. If a propeller is feathered in flight, the engine synchronizer should be turned off. If any correction in rpm is required, or if any instability is detected, the engine synchronizer system should be turned off and then reset.

Following are some possible faults and the effect of such faults.

If the master engine should malfunction, its rpm will either increase or decrease; rpm of the slave en-

gine will follow suit until the corrector motor output shaft reaches the maximum or minimum stop.

If the master alternator should fail, rpm of the slave engine will decrease until arrested by the minimum stop in the corrector motor.

If the slave engine should malfunction, the corrector motor will drive the output shaft onto either the minimum or maximum stop, depending on whether the slave engine overspeeds or underspeeds.

If the slave alternator should fail, the corrector motor will drive the output shaft onto the maximum rpm stop.

If the output shaft on the corrector motor should fail, synchronization by the corrector motor is not possible, but the selected rpm will be maintained by the friction device on the linkage system.

The synchronizer is switched off when the aircraft is coming in for a landing. If the switch fails in the ON position, then engines will be synchronized and the switch should be turned off; but, it is still possible to land, although the pilot would have to take greater care with the manipulation of the power levers.

### PROPELLER OPERATING CYCLES

The following information will help the pilot to understand the propeller cycle, and to examine the function of the various operating conditions. The effects of the various types of failure under different operating regimes will assist the pilot in failure analysis.

#### ENGINE STARTING

With the propeller stationary, the blades normally rest on the ground fine pitch stop at 0°, and the engine is started with the blades on the stop. With the propeller stationary, pitch can be returned to 0°, if the blades are at any other setting, by moving the condition lever to CRUISE LOCKOUT, and starting the feathering pump.

Both throttles must be at FFPS Withdrawn position, indicated by illumination of FFPS CIRCUIT lights, and the blades must be at 0° as indicated by blade alignment marks before any attempt is made to start either engine. This will assure that the relays are energized and the pitch coarsening circuits rendered inoperative.

If the engine fails to light within 20 seconds, as indicated by failure of TGT to rise or, if having lit, engine rpm fails to rise above 2000 within 30 seconds, the condition lever should be placed to FUEL OFF and the engine start selector switch to Safe. No further attempts to start should be made until the propeller has stopped rotating. Application of the propeller brake to ON then OFF, or selecting the engine start switch to SAFE then LH or RH, is required to reinitiate the starting cycle.

If there has been any delay in moving the condition lever to FUEL OFF, a motoring cycle should be performed before attempting to restart the engine. A motoring cycle should also be performed after a second failure to start.

#### GROUND RUN AND TAXI

Ground running and taxiing is undertaken with the flight fine pitch stops withdrawn and with the pitch coarsening circuit through the hub switch at 17° rendered inoperative. This allows either engine to be

accelerated without the flight fine pitch stop being engaged.

Idling will normally be with the blades on the 0-degree stop. Increase of fuel flow above idling results initially in an increase of rpm only, since the actual rpm is still below the selected rpm, and the controller unit accordingly holds the blades firmly on the ground fine pitch stop. Ultimately, with further increase of fuel, rpm will reach 11,800 and then remain constant while the blade angle changes. When fuel flow becomes sufficient to provide approximately 590 BHP, rpm and blade angle both increase as the fuel flow or throttle setting is increased. Above 590 BHP, the thrust response to a rapid throttle movement may be incorrectly sensed initially, although the ultimate response will be correct. The thrust available up to 590 BHP is adequate for taxiing and maneuvering and, up to this level, thrust response to throttle movement is correctly sensed at all times.

Ground running of either engine up to maximum rpm for testing is possible since the flight fine pitch stops are rendered inoperative unless both throttles are advanced beyond 13,000 rpm. Adequate power is available for ground maneuvering and taxiing without the engines exceeding 13,000 rpm.

#### TAKEOFF

Opening the throttles for takeoff releases the flight fine pitch stop relays, making the mechanical stops effective and ensuring that once the blades are above the flight fine pitch stop at 19°, the stops will be locked in for the duration of the flight. At the same time, the pitch coarsening system working through the hub switches at 17° will be rendered operative.

The FFPS CIRCUIT light, illuminated when the third oil line solenoids are energized, goes out when both throttles are opened for takeoff; and the ground fine pitch (BELOW FFPS), lights working through the hub switches at 17°, extinguish when the blade pitch of both propellers exceeds 17° as power is applied. If the FFPS CIRCUIT light does not go out, the takeoff is to be discontinued.

For takeoff, the engine condition lever is moved beyond the normal FUEL ON position, to the cruise pitch stops withdrawn (CRUISE LOCKOUT) position. After the aircraft is airborne, the condition levers are moved back to their normal positions.

If an engine fails during takeoff, engine torque drops to a value where thrust is negative, and the torque-sensitive pitch-coarsening system comes into action, starting the feathering pump motor and driving the failed engine's propeller to feather. Hence, autofeather coarsening.

If failure is only temporary and positive torque appears again, prior to full feathering, the system reverts to normal governing. Movement of the condition lever to feather on the failed engine has the effect of disarming the torque-sensitive feathering system on the operating engine.

If the autofeather system should fail also, the blades will come to rest either on the cruise stop or on the flight fine pitch stop, depending on airspeed and altitude. Windmilling drags and decreased rpm at this angle can be reduced by resorting to manual feathering.

A loss in engine torque oil pressure brings the auto-feather pitch coarsening system into action. A loss of thrust and a drop in rpm will result. Should oil pressure return before the blades are feathered, the system will revert to normal operation; otherwise, the blades will be driven straight through to the feathered position, because the feathering pump will be operating. Engine temperature will increase to some extent but the rapid drop in rpm will preclude any serious overheating. The condition lever should be placed in Feather as soon as practicable to stop the feathering pump.

A failure resulting in inadvertent reduction of pitch during takeoff will have the effect of causing an increase in rpm, since fuel flow will be constant while propeller power absorption is reduced. The blades will move back into the flight fine pitch stop, and rpm may rise until the overspeed governor commences to cut fuel; rpm will be maintained at about this level, even if the aircraft is accelerated to a higher airspeed, as is likely on takeoff.

Should the overspeed fuel governor fail to operate in addition to the main failure, then rpm will rise until an equilibrium is reached between the compressor plus propeller power absorbed and turbine power delivered. Following such a failure, the pilot will have to throttle back to check airspeed.

A failure which leads to inadvertent increase of pitch, will cause high engine temperatures, and the propeller should be feathered.

#### EN ROUTE CLIMB AND CRUISE

As aircraft speed increases to approximately 180 knots true airspeed, blade pitch will exceed 29°. However, until a hub switch at 31° has opened, the 29-degree stops are not effective and it is considered that the blade angle must exceed 31° before it can be regarded as certain that the hub switches have opened and the 29-degree stops are effective, as evidenced by the CRUISE STOP CIRCUIT light going out.

To exceed 31° under the most adverse circumstances, an airspeed of 180 knots true may be required; therefore, up to 180 knots, there is always the possibility that, following a governor failure, the blade pitch angle could reduce to the flight fine pitch stop at 19°. Investigation has indicated that the propeller is safe under any condition up to a forward speed of at least 227 knots.

In normal operation, as the blade pitch on any one propeller exceeds that corresponding to the actual setting of the 31-degree hub switch, the circuit energizing the cruising pitch stop solenoids on both propellers will be deenergized and the 29-degree stops will become effective; however, the CRUISE STOP CIRCUIT warning light will remain on until blade angle of both propellers is above 31°. The CRUISE STOP CIRCUIT light will go out above 31° to show that the stops are effective, and the pilot can continue to build up airspeed since, in the event of a governor failure, the 29-degree stops will limit windmilling drag and rpm values to acceptable limits up to and beyond V<sub>NE</sub> speed.

In these flight regimes, aircraft speed is sufficiently high for control to be maintained without difficulty, following a failure, provided that propeller drags are not excessive.

If airspeed is high, and selected rpm is relatively low, it might be possible to constant-speed windmilling with the blades clear of either of the mechanical 29-degree stops, but it is most probable that the blades will reset on one of the stops and that rpm would be below the selected value.

Failure of the cruise pitch stop to withdraw will be indicated to the pilot by a reduction of rpm below the selected value and by a rise in TGT. When airspeed falls below the value applicable to the 29-degree pitch, the pilot's first action is to move his condition lever to CRUISE LOCKOUT. If the CRUISE STOP CIRCUIT light flickers continually during cruise, indicating system fault, the pilot should move the pitch stop circuit switch to EMER (figure 13). This blocks automatic removal of the stops, the CRUISE STOP CIRCUIT light extinguishes, and the pilot may continue to fly at high airspeeds. If the EMER position was used, the selector

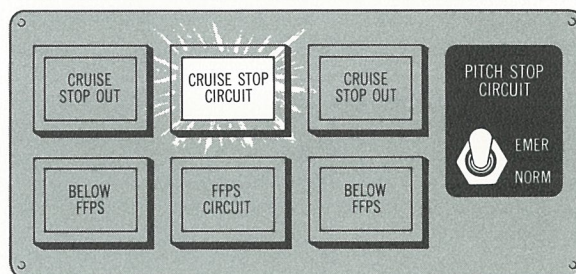


Figure 13. Selector switch is moved to EMER position whenever Cruise Stop Circuit switch flickers continually, indicating a system fault.

must be returned to NORM at some lower airspeed to effect automatic removal of all the stops, or the condition lever must be placed in CRUISE LOCKOUT and the engines shut down immediately after touchdown.

#### APPROACH AND TOUCHDOWN

Descent can be made under widely varying conditions of airspeed and power setting, depending on operational circumstances, while a standoff will normally involve comparatively low-speed flight at a small throttle opening.

The results of loss of engine oil pressure depend on position of the power lever; i.e., on whether the auto-feather system is operative or not. If the system is not operating, the failure might not be apparent until the loss of oil pressure causes the propeller controller unit to malfunction, in which case the failure develops into an inadvertent reduction of pitch.

The approach is made at the minimum selectable rpm with the throttle adjusted to give the necessary power for the rate of descent required. During approach, the condition levers are moved to select withdrawal of the cruising pitch stops.

After touchdown, the throttle T handle is moved to the ground position to avoid overheating the engine, thus removing the 19-degree stop and rendering inactive the pitch coarsening system through a lockout circuit. Movement of the selector lever illuminates the FFPS CIRCUIT warning light. Since, at touchdown, rpm with the throttle closed is normally below 12,500, the controller unit will drive the blades down to the stop at 0°.



## Loss of Directional Control

*This article is based on a study made by the Technical Services and Training Center at TWA.*

BRAKING AND CONTROL of aircraft on wet and slush-covered runways has received coverage in industry publications and in FAA and NASA reports. See also the *Convair Traveler* for September/October 1962. This article discusses controlling and stopping aircraft on dry runways and the cornering capability of the tires.

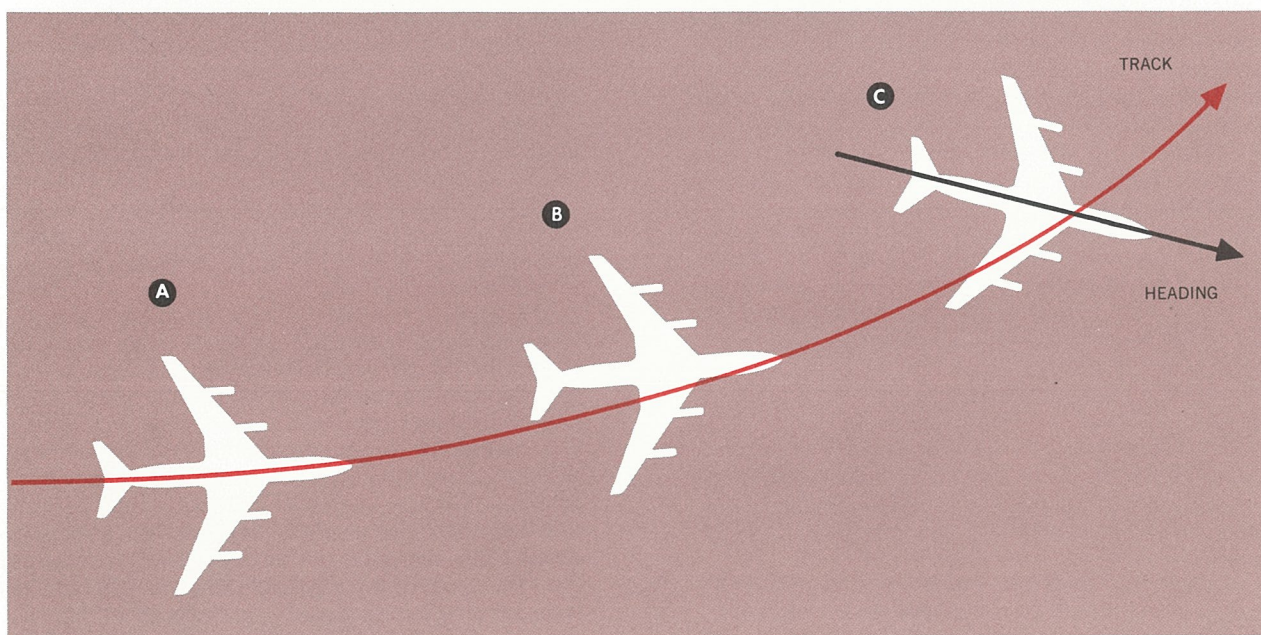
Incidents of loss of directional control during landing or aborted takeoffs on dry runways has been characterized by the ability to control the heading of the aircraft but not its track.

A number of factors may result in loss of directional control on a dry runway — improper or ineffective braking, flat tire(s), asymmetrical thrust resulting from inoperative engine(s) and/or thrust reversers, and crosswinds.

To recover from loss of control, or to corner successfully, knowledge of three important factors is involved: velocity and its relationship to centrifugal force, coefficient of friction, and proper pilot technique.

During loss of directional control, while the pilot is attempting to regain the airplane track, he is fighting the curve, or turn. On any curve, velocity determines how much centrifugal force, or energy, is being generated at any point on the curve. Centrifugal force is generated by changing direction of the airplane at speed. This force causes the pilot to lose directional control if he corners too fast.

A TWA engineering study of this problem pointed out that on a dry runway, the cornering capability of the tires was the greatest single force available to the



*Figure 1. Effects of reverse thrust application on No. 4 engine.*

pilot to control the track of the airplane, just as it is on an automobile. This study sought the answers to the following related questions.

1. What major factors, aside from runway conditions, affect the cornering capability of the tire?

2. To obtain the maximum cornering capability from a tire, can you have any braking applied?

3. When using differential braking, will the amount of braking applied affect the cornering capability of the tires?

4. When a tire has optimum braking applied (as maintained by the anti-skid system), does the tire have any cornering capability remaining?

This study, besides exploring the answers to these questions, presents additional factors that will help the pilot to recognize and handle directional control problems that may develop.

To best illustrate the problem, TWA used a composite case where loss of directional control occurs after landing or during an aborted takeoff. In all cases examined, the aircraft started to veer from its desired heading. This could have been caused by any number of circumstances such as differential thrust, crosswind, flat tire, dragging brake, etc.

The case to be discussed is based on the abnormally slow acceleration of the number 4 engine when applying reverse thrust. See figure 1A.

Obviously, if immediate corrective action is not taken, the forces will cause the aircraft heading and track to change to the left, as shown in figure 1B. At this point, reverse thrust is now symmetrical and the pilot attempts to return the aircraft to the center of the runway, using differential braking. The amount of deviation from the desired heading and track influences the pilot as to how much differential braking to apply.

For purposes of explanation, it is to be assumed that heavy differential braking is used. As a result of the heavy differential braking, the aircraft heading starts to change but the track remains relatively unchanged. This is indicated in figure 1C.

This unchanging track may not be readily detected by the pilot since he is sitting so far ahead of the main gear. In fact, the differential braking may restore the aircraft to the desired heading at such a rate as to create the false illusion to him that the aircraft has also assumed the desired track.

*Why didn't the change in heading produce a corresponding change in the track?*

Since the capability is there, there is no reason why the aircraft track cannot be returned to the center of the runway just as fast as it left it. The only significant difference between the aircraft configuration at 1B versus 1C is the braking being applied. Thus, braking must adversely affect the cornering capability of the tires.

To change the track of an aircraft on the ground, a force must be applied at right angles to its heading (figure 2). This force can be applied by:

Aerodynamic sideforce due to angle of sideslip.

Lateral thrust component due to angle of sideslip.

Tire cornering force.

The tire cornering capability on a dry runway is approximately 20 times greater than any other single force the pilot can produce to turn the aircraft.

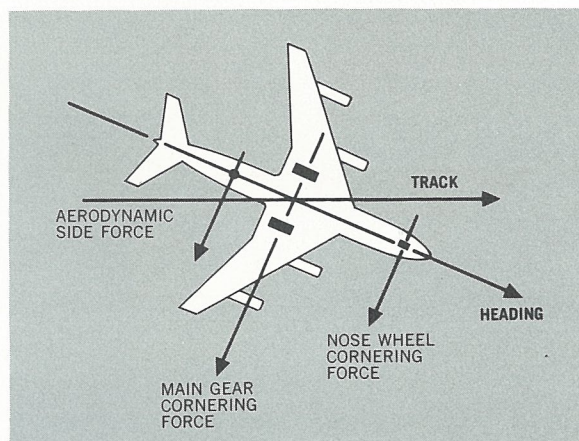


Figure 2. Relationship of heading and track.

A sideslip or slip angle is required to maintain any side force and can be produced by rudder action, differential thrust, differential braking, or nose wheel steering. These controls can produce only a change in heading and in themselves cannot change the track.

To best understand why the change in heading did not correct track let us examine what happens to the tires when subjected to this condition.

Figure 3A shows a wheel with a braking force applied to it. From the footprint area of this wheel let us remove a plug of rubber and see how it reacts to this braking force (figure 3B).

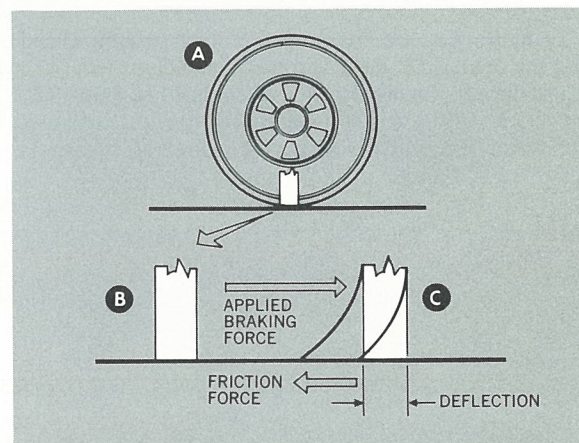


Figure 3. Application of force to plug of rubber.

When braking force is applied to the plug of rubber resting on the runway, the rubber will deflect and, since rubber is elastic like a spring, the deflection will be proportional to the applied force (figure 3C). As this force increases, the deflection increases until the force is equal to the maximum static (breakaway) friction force available between the rubber and the runway. When this point is reached, the plug of rubber will begin to skid in the direction of the applied force (figure 4A). Now, placing this plug of rubber back into the wheel, it is easy to see what happens to the tire when braking forces are applied (figure 4B).

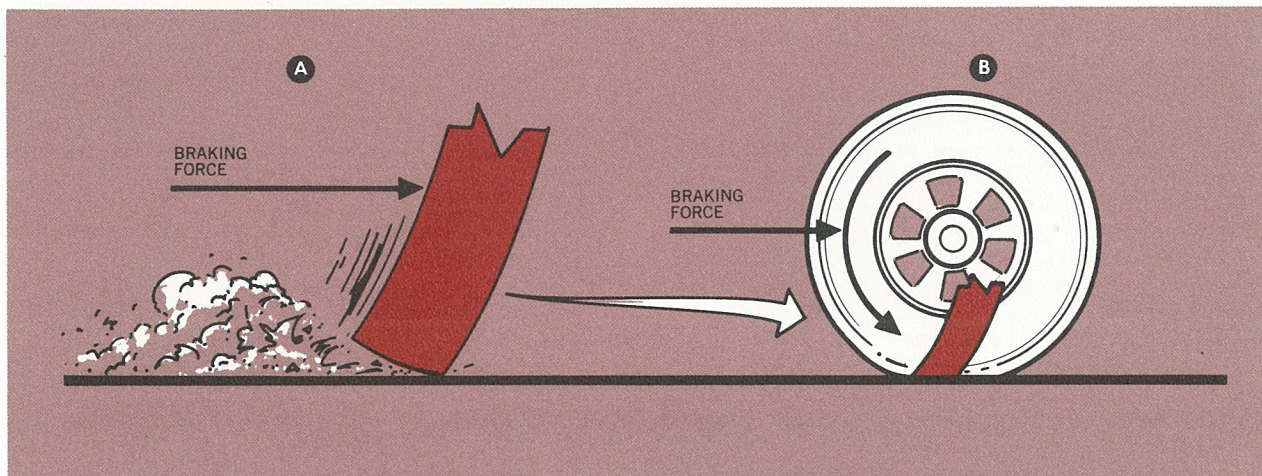


Figure 4. Rubber plug skids in direction of applied force.

The tires of the aircraft in this example, however, have an additional force acting on them. This additional force, which is a side force, is the cornering capability that is created by the tire rolling at a slip angle. Slip angle is the angular difference between the rotating plane of the wheel and its direction of motion. As indicated in figure 5, these principles are the same as those involved in an automobile when turning a corner.

To illustrate the cornering capability we will again use the "plug of rubber" approach, but from a different vantage point—one of looking up into the tire foot-print.

In figure 6A, we have a tire rolling straight ahead and the centerline of the tire tread is undistorted. (The black dot represents the plug of rubber.) In figure 6B, the tire is rolling at a slip angle and some distortion of the tread centerline occurs. The plug of rubber is deflected as shown.

The deflection produces a force in the direction of deflection, just as before, and is the cornering force of the tire. Adding braking to this cornering wheel causes the plug of rubber to be deflected further to the rear, opposite the direction of rolling (figure 6C). This causes the resultant force on the plug to swing more rearward toward the line of motion, reducing the force in the side direction and increasing the force in the rearward direction.

The side force referred to is the actual cornering capability of the tire. With the plug subjected to the greatest braking force it can sustain without skidding, there will be little, if any, cornering capability available when a slip angle is induced.

We have all experienced this same principle in an automobile. If we enter a curve on a highway at a speed that slightly exceeds the limit of tire cornering capability (figure 6B), the deflection of the tires results in the car "drifting off" the intended track.

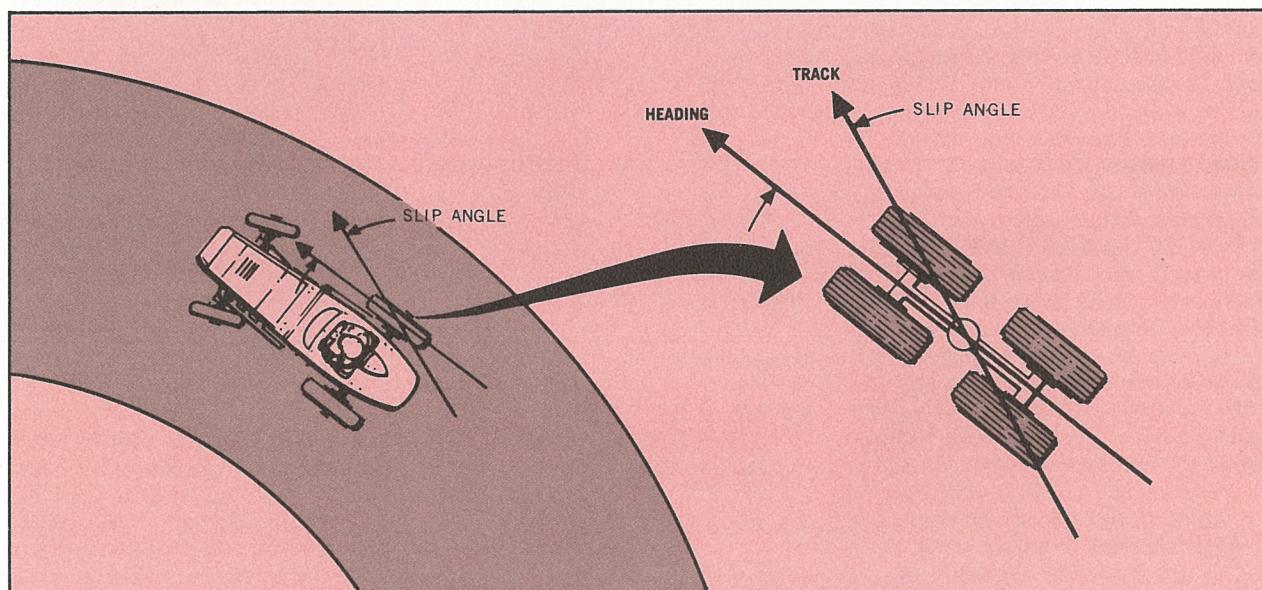


Figure 5. Cornering principles for aircraft and automobiles are similar.

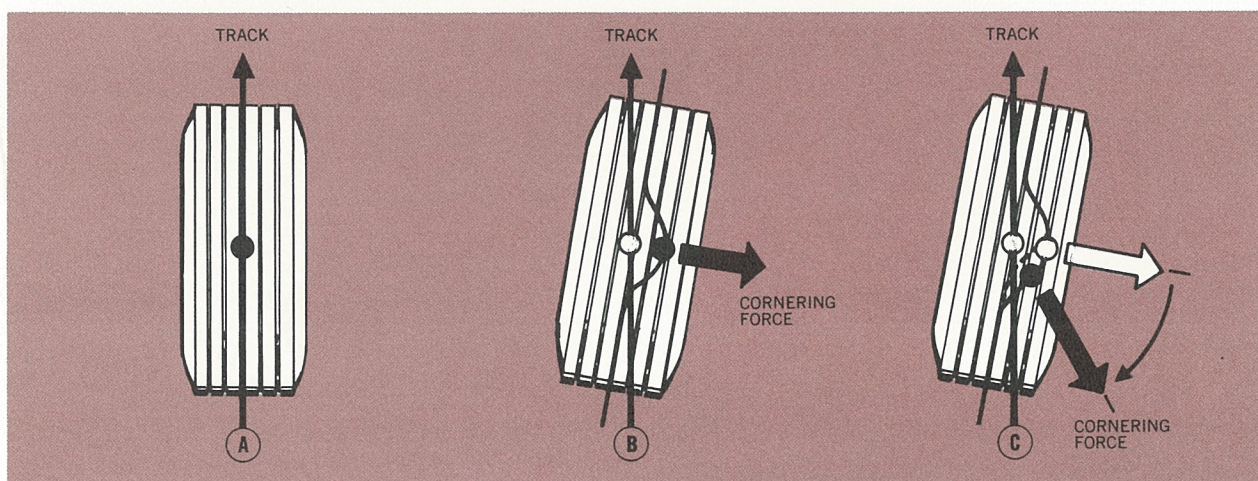


Figure 6. Deflection of rubber plug when tire is rolling at slip angle.

Application of any brakes in this situation will increase the 'drift' because of the reduction in the tire cornering capability (figure 6C). If an attempt is made to *tighten the turn* (increase the slip angle), to *apply too much braking*, or to *increase speed materially*, the tires will start to skid.

From this analogy it can be seen that the track of an aircraft can be changing significantly without the tires skidding. Also, changing the aircraft heading to increase the tire slip angle does not always result in a change in the aircraft track. Where heavy differential braking is used to change the aircraft heading, this same braking may *prevent* a change in the aircraft track because it has reduced the cornering capability of the tires.

#### CONCLUSIONS:

The foregoing analysis of tire characteristics brings to light several conclusions which will answer the four questions that were asked earlier.

1. To obtain the maximum cornering capability, a wheel must be rotating freely (no braking) at approximately a 15-degree slip angle on a clean dry runway. Maximum cornering capability will be *reduced* by any or all of the following factors:

Other than a clean, dry runway.

Greater than maximum slip angle for existing conditions.

Application of brakes.

2. When a wheel is producing a cornering force less than its maximum capability, any braking will reduce its cornering capability.

3. If a wheel is operating at its maximum *braking* capability (as maintained by the anti-skid system), little, if any, cornering capability is available regardless of slip angle.

4. When a wheel is producing its maximum cornering capability for the existing conditions, any braking will immediately result in the loss of practically all cornering capability.

5. With the cornering capability of the tires lost or even reduced, other existing side forces on the air-

craft may become predominate and adversely affect its track.

Because of the number of variables involved in any case where directional control becomes a problem, no set procedure can be recommended to return the aircraft to the desired track. The facts presented in this study, however, lead to several considerations that may be helpful if such a problem is encountered.

Touching down or starting the takeoff run in the center of the runway obviously will provide the greatest lateral margin of runway to take corrective action, should a directional control problem develop.

Because the initial deviation between heading and track may not be detectable in the cockpit, corrective action *must* be taken at the first indication of such a deviation.

The cornering capability of the tires on a good runway surface is the greatest single force available to change the aircraft track.

Where a significant difference between the aircraft heading and track develops, especially on a good runway surface, the application of moderate to heavy braking greatly reduces the cornering capability of the tires. To regain cornering capability it may be necessary to partially, or even completely, release the brakes assuming, of course, sufficient runway is available.

Tire cornering capability, like braking, is dependent on the condition of the runway.

Nose wheel steering, although designed for slow-speed operation, *may be* effective in recovering the desired track at speeds up to 100 knots, providing lateral control is not a problem. It must be considered that the nose wheel tires are governed by the same rules for cornering as the main gear tires. Any excessive slip angle will reduce cornering capability and create a hazard of peeling off the tires. Therefore, use of nosewheel steering must be used with *prudence*, if it is to be beneficial.

An extensive study being carried out by NASA will investigate wheel cornering and braking characteristics. Any additional significant facts derived from this investigation will be published in the Traveler.

## From Props to Turboprops

THE FOLLOWING HINTS will assist maintenance personnel in safely making the transition from reciprocating engines to the Dart turboprops.

Prop wash is perhaps the greatest hazard associated with the Dart engine, and personnel should give the prop-wash area a wide berth during engine run. Unlike the prop-wash on reciprocating engines, on turboprops it has a tendency to pull and tumble the individual into the propeller instead of blowing him back and away from it.

Blast and heat from the jet tailpipe is carried over the wing and diffused over the trailing edge; hence, blast and heat are not considered dangerous to personnel on the ground, since the tailpipe is at a height that precludes this hazard.

The nickel cadmium batteries used on the Dart contain potassium hydroxide (KOH), which is about as caustic as kitchen lye and should be treated with the same respect. Following are a few precautions to be observed:

Wear rubber gloves, apron, and face shield when handling potassium hydroxide.

If any liquid is spilled, or comes in contact with the skin, immediately flood the area with cold water until the physician arrives. Wash clothing on which KOH has been spilled. Boric acid solution, vinegar, or citrus fruit juice may be used to neutralize potassium hydroxide.

Do not store nickel cadmium and acid type batteries in the same area. Do not use acid bearing tools on nickel cadmium batteries because use of these tools could contaminate the electrolyte.

Before cleaning nickel cadmium batteries, close vent plugs. Do not leave plugs off for too long a period because exposure to air contaminates the electrolyte with  $\text{CO}_2$ .

Use only distilled water to adjust level of electrolyte.

Use extreme care when working around the top of the battery. Severe sparking could result if uninsulated tools are dropped on the cell terminals. Lift case covers off vertically so that edge of metal cover does not short across the terminals.

Monobromotrifluoromethane ( $\text{CF}_3\text{BR}$ ), used in the APU fire extinguishing system, is nontoxic and noncorrosive; however, it can be harmful. Avoid breathing the vapors or allowing the liquid to come in contact with the skin. If leakage in a closed area is suspected, do not enter the area until it is well ventilated and the vapor removed. Use a Halide (Presto-Lite or equivalent)

sniffer to ensure that the area is safe to enter. Unlike chlorobromomethane (CB),  $\text{CF}_3\text{BR}$  does not require purging of the area after use.

The vapors given off by methanol used in the water/methanol mixture in the Dart, are toxic. Repeated inhalation has the same effect as internal consumption. Any spills on the skin are to be promptly washed off. Objects or areas on which methanol has been spilled, are to be wiped off immediately so as to prevent corrosion. Since methanol may be lost through evaporation, a check of the mixture remaining in the tank is to be made as follows:

Into a clean glass container, drain a sample of the water/methanol mixture from the tank drains located under the fuselage, left and right of the airplane centerline.

Check to see that sample is clear and free of sediment or suspended matter.

Check specific gravity with a hydrometer graduated in the range of 0.8450 to 1.0000. Hydrometer reading is then to be plotted on the graphs in Chapter 12 of the Maintenance Manual, using the temperature at time of sampling to determine if specific gravity falls within specified limits.

Add water or methanol as required to correct the deficiency.

The synthetic oil used in the engine oil system is a transparent oil that is difficult to see on the dipstick; thus, care is required when checking oil level.

Do not stack anything on, or drag anything over, the ram air scoop heating elements; avoid contacting them with sharp objects.

With the propeller in feathered position, exercise care when opening cowl panels to avoid striking the blade.

Before performing any work on the engine ignitors, remove the low-tension leads and wait at least one minute to permit electrical energy to dissipate. Stored electrical energy, right after shut-down, is sufficient to cause severe, or even fatal, electrical shock. The recommended procedure for removal of the ignitor lead is to carefully loosen the terminal nut; then grasp the lead about one foot from the nut, and pull it loose.

FOD (foreign object damage) can be a problem on turboprop aircraft, even though the air intake is high above the ground. Whenever possible, start or run the engines on a smooth paved surface to minimize the possibility of picking up foreign objects which could be drawn into the compressor.

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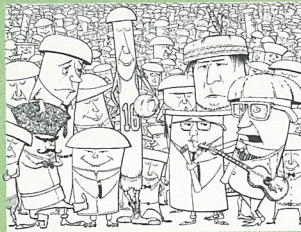
# *Convair Traveler*



*In This Issue: Coding of Rivet Type Fasteners  
Water Methanol System*

VOLUME XVIII NUMBER 4 NOVEMBER/DECEMBER 1966

## Convair *Traveler*



In This Issue: Coding of Rivet Type Fasteners  
Water-Methanol System

### OUR COVER

George Jean Nathan, editor and drama critic, said, "Great art is as irrational as great music. It is mad with its own loneliness." Would you say that this month's cover by Tony Adams is great? Would you believe irrational? Mad? We think he is trying to illustrate the variability of rivets. At least we will give him the benefit of the doubt and say that this is what the cover is all about.

# Convair *Traveler*

VOLUME XVIII NUMBER 4 NOVEMBER/DECEMBER 1966

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CONVAIR DIVISION OF GENERAL DYNAMICS



## Coding of Rivet Type Fasteners

RIVETING with driven aluminum rivets is the most common method of fastening aircraft parts. In a properly designed rivet joint, each rivet carries its proportional share of the total load and transmits its load by resisting shearing.

There are a variety of rivet sizes and head shapes made to AN standards and they usually carry AN numbers. Some rivets for special applications carry the manufacturer's code number, but most of the solid shank driven rivets in use on aircraft today are limited to the universal (round) head or countersunk (flush) head.

The rivet number indicates the head type, material, diameter and, sometimes, the length. In addition, a color code and/or a marking on the rivet head indicate type of material. The type is designated by a number—AN470 for universal head and AN426 for countersunk head, for example; this number is followed by a letter (or letters) designating the type of material, as shown in Tables I and II.

Following the letters designating the type of material is a number that indicates the diameter of the rivet in 32nds. Whenever length of the rivet is given, it follows in 16ths, preceded by a dash. For example:

AN426 AD 4 - 3

— 3/16 inch long  
— 4/32 inch (1/8) dia  
— A2117-T3  
— flush head (countersunk)

Length measurement is taken from the end of the shank to the underside of the rivet head for universal, or round head, rivets; from the top of the head on countersunk (flush) head rivets.

The designation "A" rivet is made of commercially pure aluminum and is used for riveting nonstructural parts fabricated from the softer aluminum alloys, such as 1100-F and 5056-F.

The "B" rivet is used for riveting magnesium alloy structures because of its corrosion-resistant qualities in combination with magnesium. This rivet of 5056-F material is designed for use only in magnesium structures and is not to be substituted.

TABLE I  
CODE FOR ALUMINUM ALLOY RIVETS

| TYPE DESIGN                       | ALLOY & TEMPER    | HEAD MARKING | COLOR CODE | BASIC CODES | RIVET NUMBER    |
|-----------------------------------|-------------------|--------------|------------|-------------|-----------------|
| A                                 | 1100-F            | plain        | none       | BH          | AN470           |
|                                   |                   | raised       |            | BA          | AN426           |
|                                   |                   | cross        |            | BK          | AN470           |
| B                                 | 5056-F            | plain        | gray       | BC          | AN426           |
|                                   |                   | raised       |            | BJ          | AN470           |
|                                   |                   | cross        |            | BB          | AN426           |
| AD                                | 2117-T3           | dimple       | yellow     | BM          | AN470           |
|                                   |                   | raised dot   |            | BE          | AN426           |
|                                   |                   | cross        |            | CX          | AN470           |
| D                                 | 2017-T3 (refrig)  | dimple       | red        | CY          | AN426           |
|                                   |                   | raised dot   |            | XD          | Q4326 w/washer  |
|                                   |                   | cross        |            | XE          | Q4326 wo/washer |
| DD                                | 2024-T31 (refrig) | dimple       | green      | XF          | 97-67012        |
|                                   |                   | raised dot   |            |             |                 |
|                                   |                   | cross        |            |             |                 |
| Straylor 82° fuel seal, Mod head  | 2024-T31 (refrig) | dimple       | Green      |             |                 |
|                                   |                   | raised dot   |            |             |                 |
|                                   |                   | cross        |            |             |                 |
| Crown Hd 82° fuel seal, mod       | 2024-T31 (refrig) | dimple       | blue       |             |                 |
|                                   |                   | raised dot   |            |             |                 |
|                                   |                   | cross        |            |             |                 |
| ERCO low hd, 82° fuel seal mod hd | 2024-T31 (refrig) | dimple       | black      |             |                 |
|                                   |                   | raised dot   |            |             |                 |
|                                   |                   | cross        |            |             |                 |

TABLE II  
CODE FOR NON-ALUMINUM RIVETS

| TYPE DESIGN | ALLOY & TEMPER   | HEAD MARKING      | COLOR CODE      | BASIC CODE | RIVET NUMBER       |
|-------------|------------------|-------------------|-----------------|------------|--------------------|
| M           | Monel            | Raised double dot | none            | HW         | AN427M countersunk |
| M-C         | Monel-Cad-plated | none              | natural cadmium | HX         | AN435M universal   |
|             |                  |                   |                 | XA         | Q4304 countersunk  |
|             | Stainless Steel  | none              | natural cadmium | XB         | Flat head Q4310    |

The "AD" rivet is the most commonly used structural rivet for use in aluminum alloy structures in sizes up to and including  $\frac{5}{32}$ "(-5). The 2017-T material, from which it is made, allows driving while in the hard condition (T-4).

The "DD" rivet is used in aluminum structures where strength higher than that of the AD rivet is required. This rivet is generally used in diameter sizes of  $\frac{3}{16}$  inch and larger. DD rivets are made from 2024-T31 aluminum alloy and are refrigerated before driving. They work-harden when driven, and continue to harden when aged at normal temperatures. Any subsequent driving most always causes them to crack. DD rivets that loosen are to be removed and replaced with new DD rivets.

Corrosion-resistant steel rivets are used primarily for riveting corrosion-resistant steel parts, such as firewalls, exhaust stack brackets, and similar structures. They are excellent for transmitting high shear loads and for use in high-temperature areas.

Monel rivets are used in special cases for riveting nickel alloys and high nickel steel alloys. They are more easily driven than steel; however, stainless steel rivets are preferable in stainless steel parts.

Use of steel rivets is to be avoided in thin-gage and dimpled sheets. If steel rivets are required to preclude a potential for galvanic corrosion, it may be necessary to use washers under the upset head to avoid cracking of the thin sheet, particularly if the sheet has been dimpled (figure 1).

Use of steel rivets is to be avoided in brittle materials where edge distance is marginal or where driving of the rivet may cause cracks in the part (figure 2).

Blind rivets are used in areas where only one side of the work is accessible and a standard rivet cannot be installed. These rivets have lower allowances than standard driven rivets; thus, it may be necessary to use one size larger in diameter when using them in place of standard types. Engineering approval is to be obtained before substituting a blind rivet for a standard rivet.

Both hollow and self-plugging types are a two-part pre-assembled unit (figure 3). They are similar except that in the hollow type, the plug is completely pulled through the hollow shank. In some nonstructural applications, the hollow type is sometimes preferable to the self-plugging blind rivet, since it is lighter and easier to install.

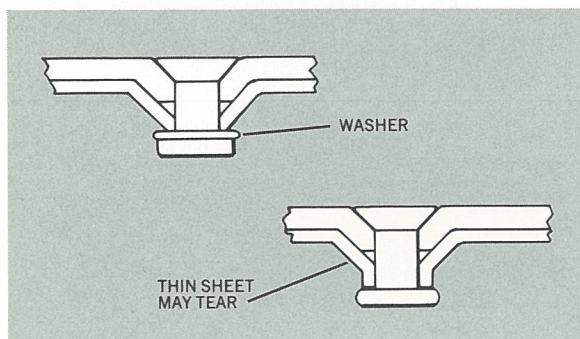


Figure 1. Steel rivets in thin gages and dimpled sheets.

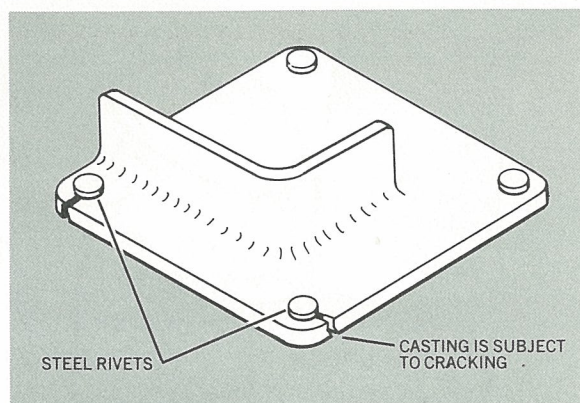


Figure 2. Use of steel rivets in castings is to be avoided.

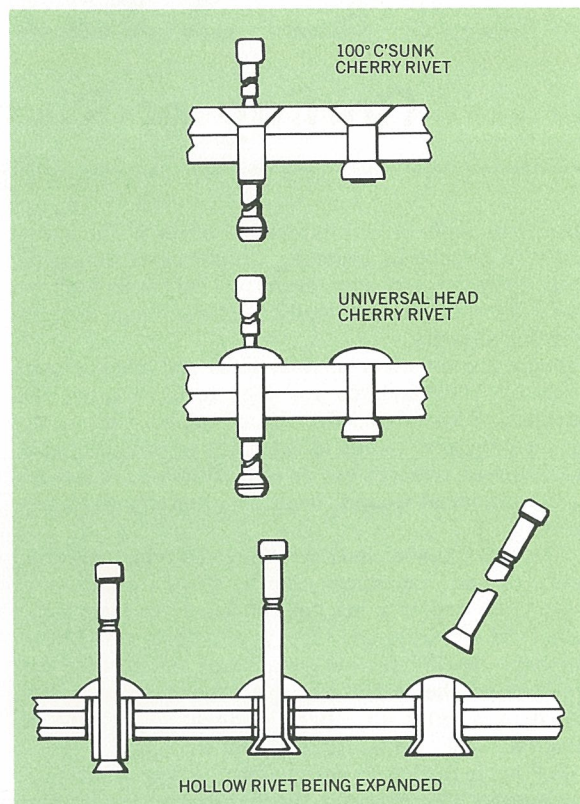


Figure 3. Hollow and self-plugging type rivets.

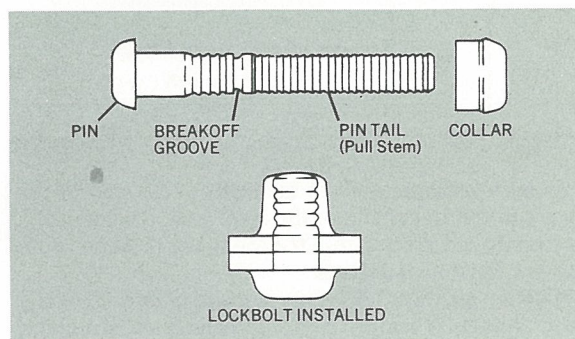
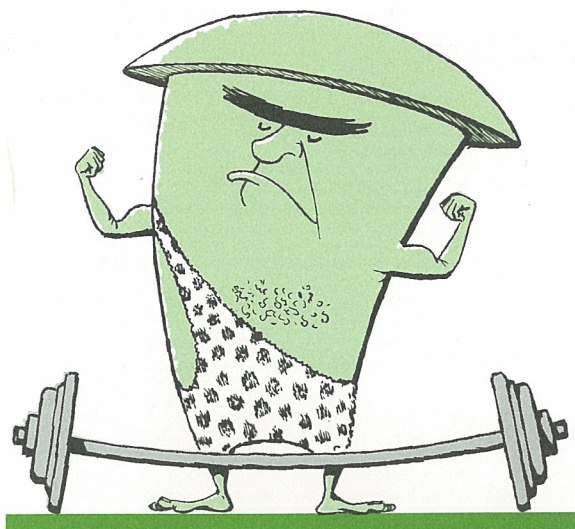


Figure 4. Pull type lockbolt.



## High-Strength Fasteners

High-strength fasteners are designed to facilitate assembly and repair in areas where the shear loads are very high and loads would normally require an excessive number of standard rivets or the use of steel bolts. The advantage of using Hi-Shear rivets instead of bolts is that they can be installed and inspected more quickly and, more important, they weigh considerably less. Tensile strength of the steel is 125,000 psi, the same as for AN bolts.

Hi-Shear rivets consist of two parts: a steel pin and an aluminum alloy collar, which forms the driven head of the rivet (see figure 4). The steel pin meets the same specifications as those of a comparable size AN standard aircraft bolt in respect to material, heat treatment, and finish.

Some typical installations are in the wing outer panel splice fitting, front and rear spars at the airplane centerline, wing-to-fuselage fittings, main landing gear beam and forgings, and flap track forgings.

Coding of Hi-Shear rivets is similar to that of other rivets. The first number, designating a certain type and size of rivet, is followed by a dash number that indicates the diameter in 32nds. Length of the rivet is designated by a second dash number that indicates the maximum grip length of the rivet in 16ths. For example:

NAS 529 - 10 - 8

— Grip length in 16ths  
— Diameter in 32nds  
— Protruding head

Collar parts are coded for diameter only: for example—NAS528-10 is for a  $\frac{5}{16}$ -inch diameter rivet.

When rivets of proper length for grip adjustment are not available, a maximum of two  $\frac{1}{16}$ -inch washers (AN960 type) of either clad aluminum alloy or cadmium-plated steel, may be used. Washers may be installed under the manufactured head, under the collar, or under the head and collar as applicable. The preferred installations, however, are those made without washers.

Hi-Shear rivets are not to be used in areas of high temperature because the aluminum alloy cannot withstand heat. At 300°F for example, the strength of the collar is approximately two-thirds that at 75°F. Over 300°, the strength drops rapidly.

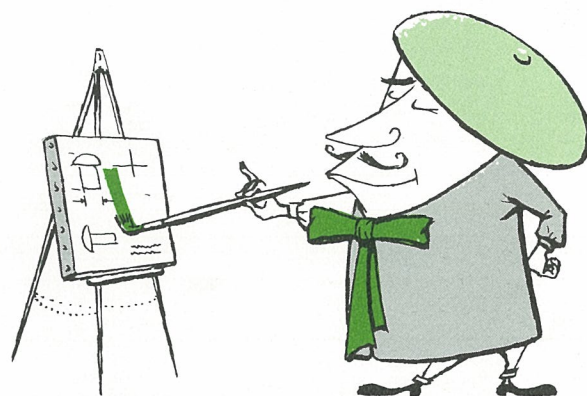
Hi-Shear rivets are excellent for high shear loads but not for tension loads.

Huck lockbolts combine the best features of both bolts and rivets, with advantages over each. This lockbolt is used in wing splice fittings, landing gear fittings, and other major structural attachments where it is difficult to drive a conventional rivet.

The Huck lockbolt is easier and more quickly installed than is the conventional rivet or bolt. Its positive uniform clinching action eliminates the use of lockwashers, cotter pins, and special nuts; it fastens as permanently as a rivet.

Like the rivet, the pull type lockbolt requires a pneumatic or hand gun for driving but, since it does not require bucking, one operator can perform the operation. When driven, it does not swell, and is driven with an interference fit to completely fill the hole. It is rigidly and permanently locked in place when driven.

These lockbolts are made of steel or aluminum alloy; although, to gain advantages of greater shear strength, the steel lockbolts are generally used. They are heat-treated to 160/180,000 psi, the same as for NAS bolts.



## Drawing Rules Regarding Fasteners

To facilitate identification and to conserve space on the engineering drawing, industry has devised a code for specifying rivet type fasteners. Tables III and IV list code numbers for fasteners used by Convair, based on NAS523. X-series rivets are special Convair types. The code consists of a symbol—a single cross—in whose quadrants are located fastener identity, size, installation requirements, etc. Quadrant orientation of the symbol is determined by compass direction.

Identity of the fastener is shown in the NW quadrant by a two-letter code, which is listed in Tables I and II. The code defines all features of the fastener except diameter and grip. Information is based on NAS523, standard practice code.

NW|NE  
SW|SE

BJ |  
AN 470 AD Rivet

TABLE III

| CONVENTIONAL, BLIND, SPECIAL RIVETS |              |                       |                    |                    |  |            |
|-------------------------------------|--------------|-----------------------|--------------------|--------------------|--|------------|
| Code                                | P/N          | PCN                   | Head Mark          | Head Type          | Description                            | Material   |
| AB                                  | AN600B       | MS20600B              | none               | Universal          | Cad-plated, Blind, Mech Expanding      | 5056-F     |
| AE                                  | AN601B       | MS20601B              | none               | 100° CSK           | Blind, Expanding                       | 5056-F     |
| BA                                  | AN426A       | MS20426A              | plain              | 100° CSK           | Natural Alum, Conventional             | 1100-F     |
| BB                                  | AN426AD      | MS20426AD             | Dimple             | 100° CSK           | Yellow, Conventional                   | 2117-T3    |
| BC                                  | AN426B       | MS20426B              | Raised Cross       | 100° CSK           | Gray, Conventional                     | 5056-F     |
| BE                                  | AN426D       | MS20426D              | Raised Dot         | 100° CSK           | Red, Driven Hard                       | 2017-T3    |
| BF                                  | AN427M       | MS20427M              | Raised Double Dot  | 100° CSK           | Bare, Conventional                     | Monel      |
| BH                                  | AN470A       | MS20470A              | Plain              | Universal          | Natural Alum, Conventional             | 1100-F     |
| BJ                                  | AN470AD      | MS20470AD             | Dimple             | Universal          | Yellow, Conventional                   | 2117-T3    |
| BK                                  | AN470B       | MS20470B              | Raised Cross       | Universal          | Gray, Conventional                     | 5056-F     |
| BM                                  | AN470D       | MS20470B              | Raised Dot         | Universal          | Red, Driven Hard                       | 2017-T3    |
| BO                                  | NAS508M      | —                     | Raised Double Dot  | Universal          | Bare, Conventional                     | Monel      |
| CX                                  | AN470DD      | MS20470DD             | Raised Double Dash | Universal          | Green, Conventional                    | 2024-T31   |
| CY                                  | AN426DD      | MS20426DD             | Raised Double Dash | 100° CSK           | Green, Conventional                    | 2024-T31   |
| DK                                  |              | 97-63004-100 thru-199 | None               | 100° CSK           | Jo-Bolt                                | Steel      |
| DR                                  |              | 97-63004-200 thru-299 | None               | Universal          | Jo-Bolt                                | Steel      |
| FK                                  | P-56S-()-100 | —                     | None               | 100° CSK           | Blind, Explosive                       | 5056-F     |
| FL                                  | P-56S-()-A   | —                     | None               | Universal          | Blind, Explosive                       | 5056-F     |
| HB                                  | —            | 97-63005-001 thru-008 | None               | 100° CSK           | Bare, Explosive, Blind                 | L-Nickel   |
| HC                                  | —            | 97-63006              | None               | Universal          | Cad-plate, Explosive, Blind            | Nickel     |
| HD                                  | BB352        | 97-63019              | None               | Universal          | Blind, Hi-Shear                        | CRES       |
| HE                                  | BB351        | 97-63023              | None               | 100° CSK           | Blind, Hi-Shear                        | CRES       |
| HF                                  | AN427C       | MS20427C              | None               | 100° CSK           | Conventional                           | Copper     |
| HH                                  | AN435C       | MS20435C              | None               | Round Head         | Conventional                           | Copper     |
| HW                                  | AN427M-C     | —                     | Raised Double Dot  | 100° CSK           | Cad-Plate & Iridite, Blind             | Monel      |
| HX                                  | AN435M-C     | —                     | None               | Round Head         | Cad-Plate & Iridite, Blind             | Monel      |
| HY                                  | —            | 97-63024              | None               | 100° CSK           | Cad-Plate, Explosive, Blind            | L-Nickel   |
| HZ                                  | —            | 97-63025              | None               | Universal          | Cad-Plate, Explosive, Blind            | L-Nickel   |
| KV                                  | AN600MP      | MS20600MP             | None               | Universal          | Cad-Plate, Blind, Mech Expanding       | Monel      |
| KZ                                  | AN604B       | MS20604B              | None               | Universal          | Non-Structural, Blind                  | 5056       |
| XA                                  | Q4304        | 97-67001              | None               | 100° CSK           | Cad-Plate, Blind                       | CRES (302) |
| XB                                  | Q4310        | 97-67002              | None               | Flat Head          | Cad-Plate, Blind                       | CRES (302) |
| XC                                  | Q4326        | 97-67000-001 thru-039 |                    | Seal Head          | Hi-Bearing, Straylor W/Washer          | 2024-T31   |
| XD                                  | Q4326        | 97-67000              |                    | Seal Head          | Hi-Bearing, Straylor, WO/Washer        | 2024-T31   |
| XE                                  | —            | 97-67007              | Insp. Dimple       | 82° Spurgeon       | Green, Solid Fuel-Sealing, Modified Hd | 2024-T31   |
| XF                                  | —            | 97-67012              | Plain              | 82° Crown Spurgeon | Blue, Solid Fuel-Sealing               | 2024-T31   |

TABLE IV  
SPECIAL BOLTS/COLLARS

| HI-LOCK BOLTS  |              |  |                              |           |          |          |                        |         |          |
|----------------|--------------|--|------------------------------|-----------|----------|----------|------------------------|---------|----------|
| BOLT           |              |  |                              |           |          | COLLAR   |                        |         |          |
| Code           | P/N          | PCN  | Head Type                    | Head Mark | Material | P/N      | PCN                    | Color   | Material |
| KD             | HL18         | 93-67101   | Universal                    | 18        | Steel    | HL70     | 96-36533-001 thru -004 | Red     | 2024-T6  |
| KE             | HL19         | 93-67100   | 100° CSK (Shear)             | 19        |          |          |                        |         |          |
| MY             | HL20         | 93-67103   | Universal Tension            | 20        | 347      | HL72     | 96-36533-005 thru -008 | Natural | 347      |
| MZ             | HL21         | 93-67104   | 100° CSK, Shear              | 21        | Steel    |          |                        |         | CRES     |
| NP             | HL31         | 93-67102   | 100° CSK, Shear              | 31        | 431      | HL70     | 96-36533-001 thru -004 | Red     | 2024-T6  |
|                |              |  |                              |           | CRES     |          |                        |         |          |
| OZ             | HL18         | 93-67101   | Universal (Shear)            | 18        | 347      | HL72     | 96-36533-005           | Natural | CRES     |
| PA             | HL19         | 93-67100   | 100° CSK, Shear              | 19        | Steel    |          |                        |         |          |
| HUCK FASTENERS |              |  |                              |           |          |          |                        |         |          |
| DA             | ALSF-T       | 96-79002-001 thru -124; -149 thru -154                 | Pan, Stump Type              | +         | Steel    | LC-C     | 92-17001-001 thru -004 | Green   | 2024-T4  |
| DB             | ASCT509T     | 96-79002-125 thru -148; -200 thru -299                 | 100° CSK, Stump              | X         |          |          |                        |         |          |
| DS             | NAS1465-1472 | 96-79010-001 thru -065                                 | Pan                          | -         | Steel    | NAS1080R | 92-17000-200 & -201    | Gold    | Steel    |
| DT             | NAS1465-1468 | 96-79011-001 thru -065                                 | Pan                          | -         | Steel    | NAS1080  | 92-17000-001 and -002  | Green   | 2024-T4  |
| DV             | NAS1456-1462 | 96-79001-002 thru -065                                 | 100° CSK                     | CT        | Steel    | NAS1080R | 92-17000-200 and -201  | Gold    | Steel    |
| DW             | NAS1456-1458 | 96-79011-002 thru -065                                 | 100° CSK                     | CT        | Steel    | NAS1080  | 92-17001-001 and -002  | Green   | 2024-T4  |
| DY             | NAS1424-1432 | 96-79001-092 thru -153; -500 thru -531; -750 thru -780 | Universal, Stump type, Shear | H         | Steel    | NAS1080C | 92-17000-005 thru -008 |         | 2024-T4  |
| EA             | NAS1414-1422 | 96-79001-001 thru -091; -250 thru -280                 | 100° CSK, Stump              |           |          |          | and -201               | Yellow  |          |
| EC             | ALSF-T       | 96-79002-001 thru -124; -144 thru -154                 | Pan, Stump type              | +         | Steel    | LC-R     | 92-17000-200           | Gold    | Steel    |
| EE             | ASCT509-T    | 96-79002-125 thru -148; -200 thru -299                 | 100° CSK                     | X         |          |          |                        |         |          |

The fastener diameter and location of the manufactured head is shown in the NE quadrant by a number/letter code. The fastener diameter is given in 32nds; location of the manufactured (preformed) head of the fastener is defined by the code F for Far side; N for Near side. When location of the manufactured head is unimportant, the code letter is omitted.

The length of the fastener is shown in the SE quadrant by the length (or in some cases by grip range) dash number of the full part number. When the part is a PCN number, the length is indicated by the significant dash number of the applicable PCN number.

The sheets to be countersunk and/or dimpled are shown in the SW quadrant by a code defined as follows:

*D* indicates a dimpling operation; when more than one sheet is dimpled, a number follows the *D* to show how many sheets are dimpled.

*C* is used to show a countersinking operation. No number is used since the number of sheets affected is determined by countersink diameter.

Protruding head rivets to have shop-formed heads installed flush are indicated by placing the numeric-letter code on the first line of the SW quadrant, which indicates the dimple or countersink operation for the shop-made head. The second line indicates the nominal angle for the shop-made head.

The flush-both-sides condition is indicated by placing the numeric-letter code on separate lines in the SW quadrant as follows:

The first line indicates the dimple (*D*) or countersink (*C*) operation for the manufactured head.

The second line indicates the dimple or countersink operation for the shop-made head.

The third line indicates the nominal angle for the shop-made head when it differs from the angle of the manufactured head. (Standard for shop-made head is 82°.)

Each fastener used on a drawing has its basic code identified in the rivet code portion of the title block or in the general notes. When the rivet block is full, or spaces are too small, the codes are continued in the general notes. There are fasteners that require that the basic code cover more than the type and material.

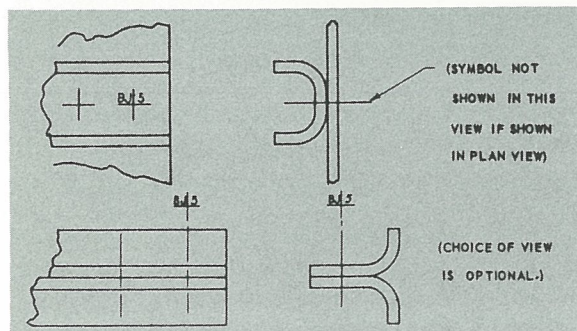
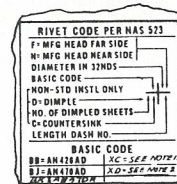


Figure 6 When only axial centerline is shown.

When identifying these, it is necessary to include additional information. For example:

Hi-Shear rivets and lockbolts must have their mating collars specified.

XC and XD basic codes cover installation of Straylor rivets as well as type and material. For this rivet, the rivet block is filled out as shown in the sketch.



General notes are as follows:

1. XC basic code = 97-67000 Straylor rivet with 99-51501 washer installed per Q2008.
2. XC basic code = 97-67000 Straylor rivet installed with head protruding, no washer.

When using lockbolts, the symbol is identical to the standard fastener code except that the washer code is indicated in the SW quadrant.

W = Washer under collar      WF = Washer far side  
WN = Washer near side      WB = Washer both sides

Information on use of the collar is added to the notes. Notes will also contain information on use of the washer. For example:

Use 22-01401-7 washer for  $\frac{3}{16}$  lockbolt  
Use 22-01401-9 washer for  $\frac{1}{4}$  lockbolt  
Use 22-01401-11 washer for  $\frac{5}{16}$  lockbolt  
Use 22-01401-13 washer for  $\frac{3}{8}$  lockbolt

Location of the symbol on the drawing is usually shown in only one view for any fastener or group of fasteners (figure 5).

When the choice of views is such that only the axial centerline of the fastener is shown, the symbol may be placed as shown in figure 6.

Intermediate groups of fasteners, varying from the end fastener in basic code, diameter, etc., require that a symbol be placed on each side (figure 7).

If crowding results from close spacing or reduced scale, the symbol is located off to one side as in figure 8.

When fasteners are used that are not covered by a fastener installation, complete dimensional installation information is called out in notes or on the face of the drawing.

The table on page 8 illustrates some of the standard rivets used on Convair aircraft.

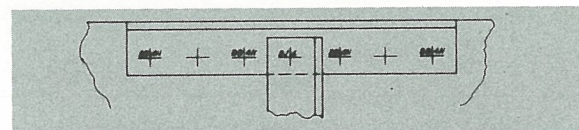


Figure 7. Location of symbols for varying fasteners.

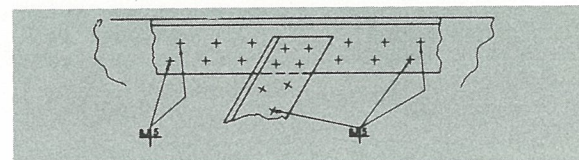
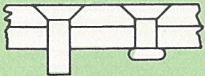
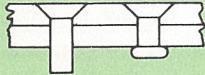
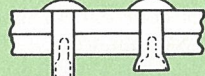


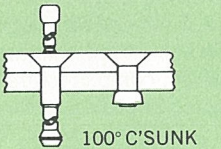


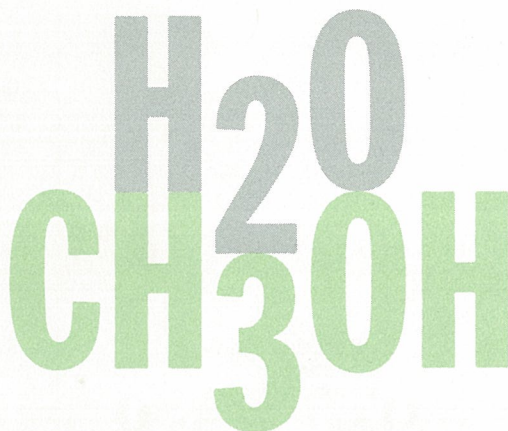
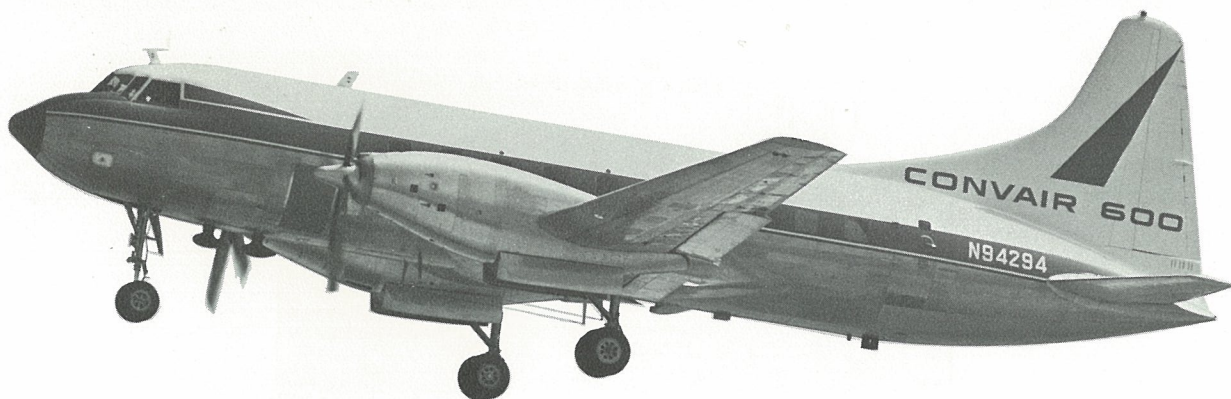


Figure 8 Location of symbols in crowded pattern.

TABLE V STANDARD RIVETS

| PART NO. | TYPE   | MATERIAL                         | REMARKS  |
|----------|--|----------------------------------|--|
| AN427    | <br>100° C'SUNK                                   | Monel<br>Copper                  | Use monel for corrosion resistance and moderate strength in CRES and nickel alloys up to 800°F.  |
| MS20426  | <br>100° C'SUNK                                   | Al Alloy                         | For general application requiring flush surface. Use type B (5056) only with magnesium parts.  |
| MS20450  | <br>TUBULAR                                       | Copper Al<br>Alloy Mild<br>Steel | Drilled shank to facilitate driving and to allow use in soft materials. Aluminum alloy tubular rivets may be used in leather, plastics, fabrics, etc. For non-structural use only. |
| MS20470  | <br>UNIVERSAL HEAD                                | Al Alloy                         | For general application. Replaces flat head types of aluminum alloy rivets. Use only type B rivets in magnesium.   |
| MS20600  | <br>UNIVERSAL HEAD<br>CHERRY RIVET              | Al Alloy<br>5056                 | Blind type protruding head rivet, used where conventional or standard rivet is inaccessible from both sides.   |
| MS20601  | <br>100° C'SUNK<br>CHERRY RIVET                 | Al Alloy<br>5056                 | Blind C'sunk type rivet used in places where conventional or standard flush rivet is inaccessible from both sides.   |
| MS20602  | <br>BRAZIER HEAD DuPONT<br>CHEMICALLY EXPANDING | Al Alloy<br>5056                 | Blind type rivet; application same as MS20600, universal head rivet.   |
| MS20603  | <br>100° C'SUNK DuPONT<br>CHEMICALLY EXPANDING  | Al Alloy<br>5056                 | Blind type rivet; application same as 100° MS20601 C'sunk head rivet.  |



## Water/ Methanol System

AN ENGINE-OIL-OPERATED water/methanol system is installed on the Rolls-Royce Dart engines to provide boosted takeoff power as well as to maintain takeoff power at elevated temperatures. Injection is automatic, after system is armed, providing water/methanol for power recovery when altitude and temperature demand. (On reciprocating engines, water/methanol is used primarily as an anti-detonant.)

A decrease in engine power due to conditions other than ISA (International Standard Atmosphere) can be restored during takeoff by automatically injecting a controlled flow of water/methanol mixture into the first-stage compressor. Injection of water is controlled by a metering unit that is sensitive to propeller shaft torque through torque-meter oil pressure and by ambient temperature through opposing atmospheric and evacuated capsules. The water/methanol unit is armed when engine speed reaches approximately 14,700 rpm.

The airframe system includes a storage tank for either gravity or pressure filling; and for each engine an electric-motor-driven pump and electric shutoff valve; a line-mounted filter; a green light to indicate satisfactory fluid pressure at the regulator inlet, and a pressure switch for operation of the fluid pressure indicator light. There is a water/methanol quantity transmitter in each tank compartment. A water/

methanol control unit is installed on each engine (figure 1).

A crossfeed system interconnects the supply to either engine in case of pump failure.

The area between wing stations 0 and 1, on each side of the airplane centerline, has been reworked to provide a cavity for installation of two interconnected flexible cells for the water/methanol solution. Each cell has a usable capacity of 75 gallons with a combined usable capacity of 150 U.S. gallons, plus 3% for expansion space. An overboard drain is installed in each cell. A line, vented to atmosphere, is installed in the right-hand cell to compensate for changes in altitude. In the event of failure of the automatic pressure refueling shutoff valves, over-pressurization of the tanks is prevented by overflow out the vent system.

The existing pressure fill adapter is connected to a refuel shutoff valve in the right-hand cell. A pilot valve, integral with the refill shutoff valve, automatically shuts off the supply at the full level. The existing gravity fill cap and pressure fill connection in the wing fillet is connected to the right-hand cell through a fitting on the upper wing surface. An amber light, adjacent to the gravity fill cap and pressure fill connection, is illuminated through a switch in the quantity transmitter which is actuated when the tank is full. A signal from the quantity transmitter also transmits tank quantity to an indicator on the instrument panel.

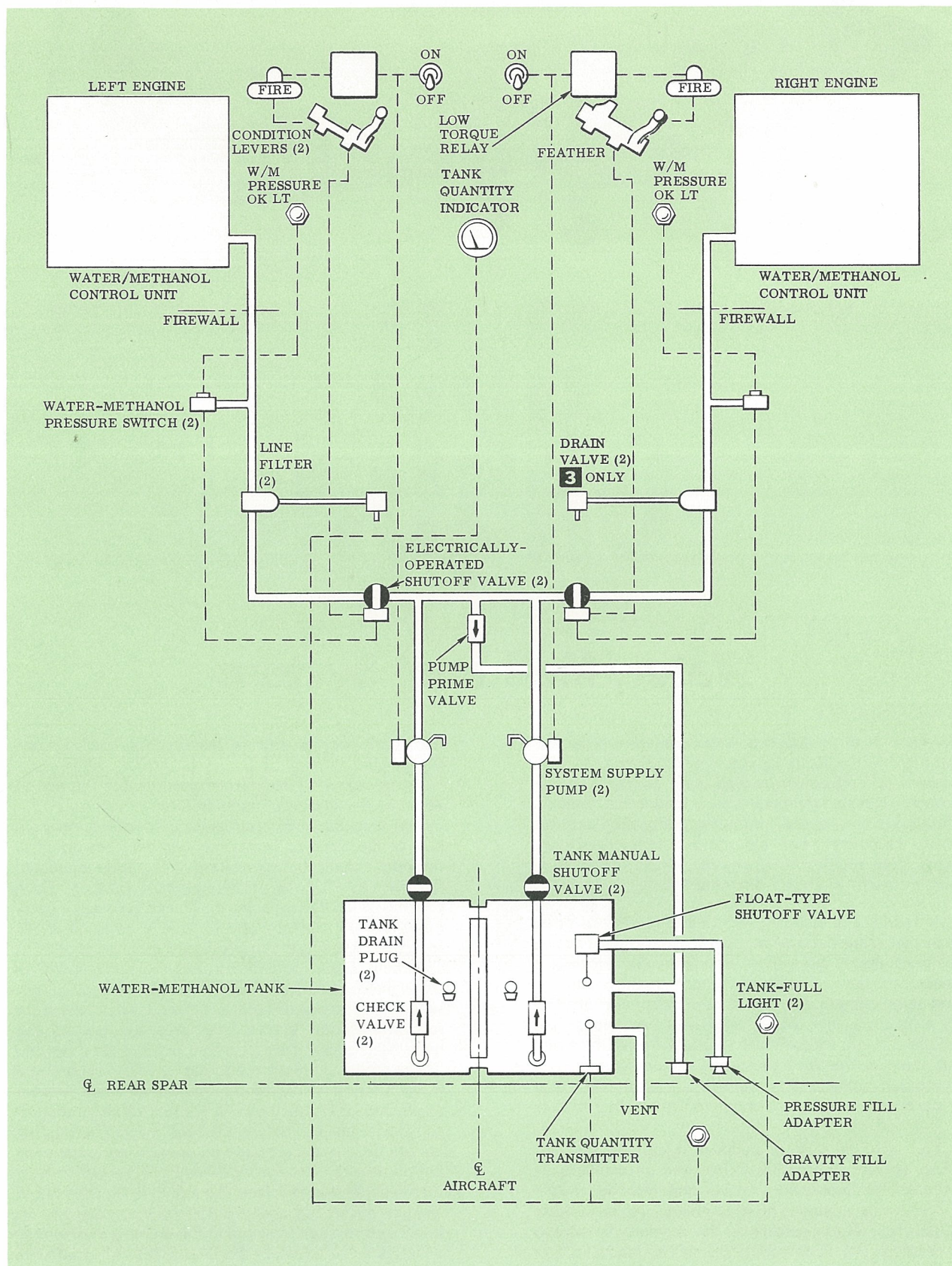


Figure 6. Interconnection of controls to water/methanol supply.

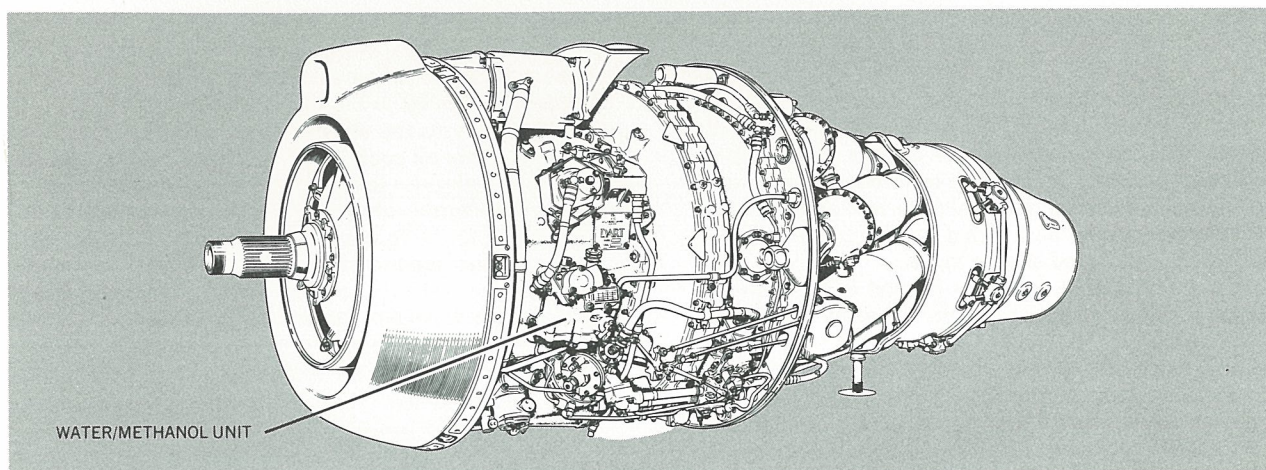


Figure 2. Location of water/methanol unit on engine.

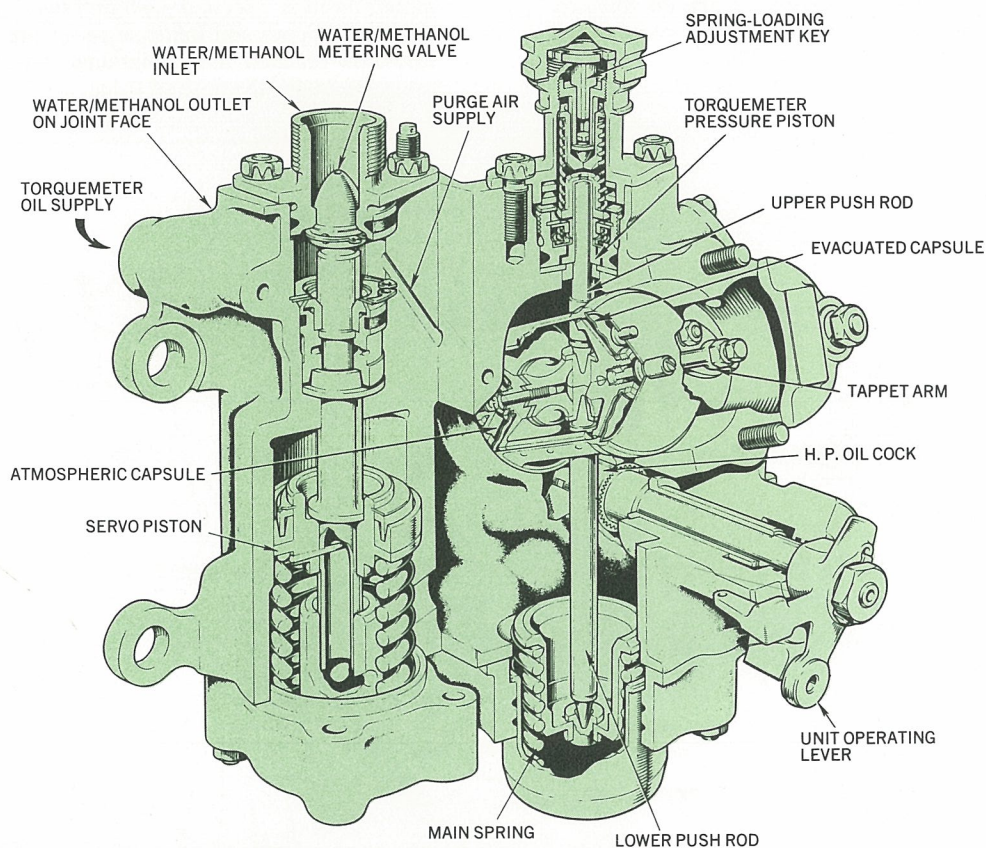


Figure 2a. Cutaway of water/methanol control unit.

A manually operated tank shutoff valve is mounted at each cell outlet connection at the forward end of the tank. The area between the forward cell bulkhead and the front spar is utilized for installation of two 200-volt ac pumps, two line shutoff valves, and the connecting lines. The supply lines are routed through the front spar and outboard along the spar to each nacelle.

A filter is installed in the supply line upstream of the shutoff valve. On the 600, the filter is located in the wheel well area; on the 640, it is located in the inboard

wing leading edge on the front spar. A pressure switch is located in each nacelle forward of the original fire-wall.

A water/methanol control unit (figure 2) is installed on the left-hand side of each engine. The control unit is a complex assembly consisting of a metering valve, an integral servo piston, a control system, and a servo system, which together determine the requirement, and control the amount of water/methanol injected into the engine.

The servo system provides the positive force for actuating the metering valve. It consists essentially of a high-pressure oil cock, the shuttle valve, and the servo piston which is connected to the metering valve.

The high-pressure oil cock is a rotary valve housed in a bore in the unit casing. The cock is coupled to a shaft terminating at an external lever connected to the engine control linkage. Internal ports in the casing connect the cock outlet port with a housing containing the double conical-ended shuttle valve.

The shuttle valve, which is housed in the capsule chamber is fully floating between two seats. The inner seat is supplied with high-pressure oil; the outer seat connects with the spill-oil chamber. The pressure differential between the high-pressure oil supply and the spill oil to the engine through the capsule chamber, provides an intermediate servo pressure for metering valve actuation. The servo pressure varies with shuttle valve position, as determined by the control system.

The water/methanol system is armed by two switches that activate the W/M delivery pumps and the DC-operated shutoff valves. The flow of water/methanol is regulated in the unit by the metering valve

which is normally held in the closed position by the servo spring. The metering valve is opened against spring pressure when the shuttle valve in the servo system admits oil to the top of the servo piston.

Oil supply to the shuttle valve is controlled by the high-pressure oil cock, which is opened by a linkage as the pilot's throttle lever approaches the takeoff position. The shuttle valve meters high-pressure engine oil according to the forces that position the capsule. The forces which tend to close the shuttle valve drain are torquemeter oil pressure and spring pressure. These forces are adjusted by the atmospheric pressure acting on the capsule assembly. Forces, operating through the pushrods, render the unit sensitive to pressure altitude (see figure 3).

Torquemeter pressure, transmitted to the capsule assembly through a piston and pushrod tends to bleed off servo pressures standing at the metering valve piston. This force is opposed by spring pressure transmitted through a second push-pull tending to close the bleed-off poppet and increase servo pressure. Equilibrium is reached and maintained when the torque pressure attains the desired value.

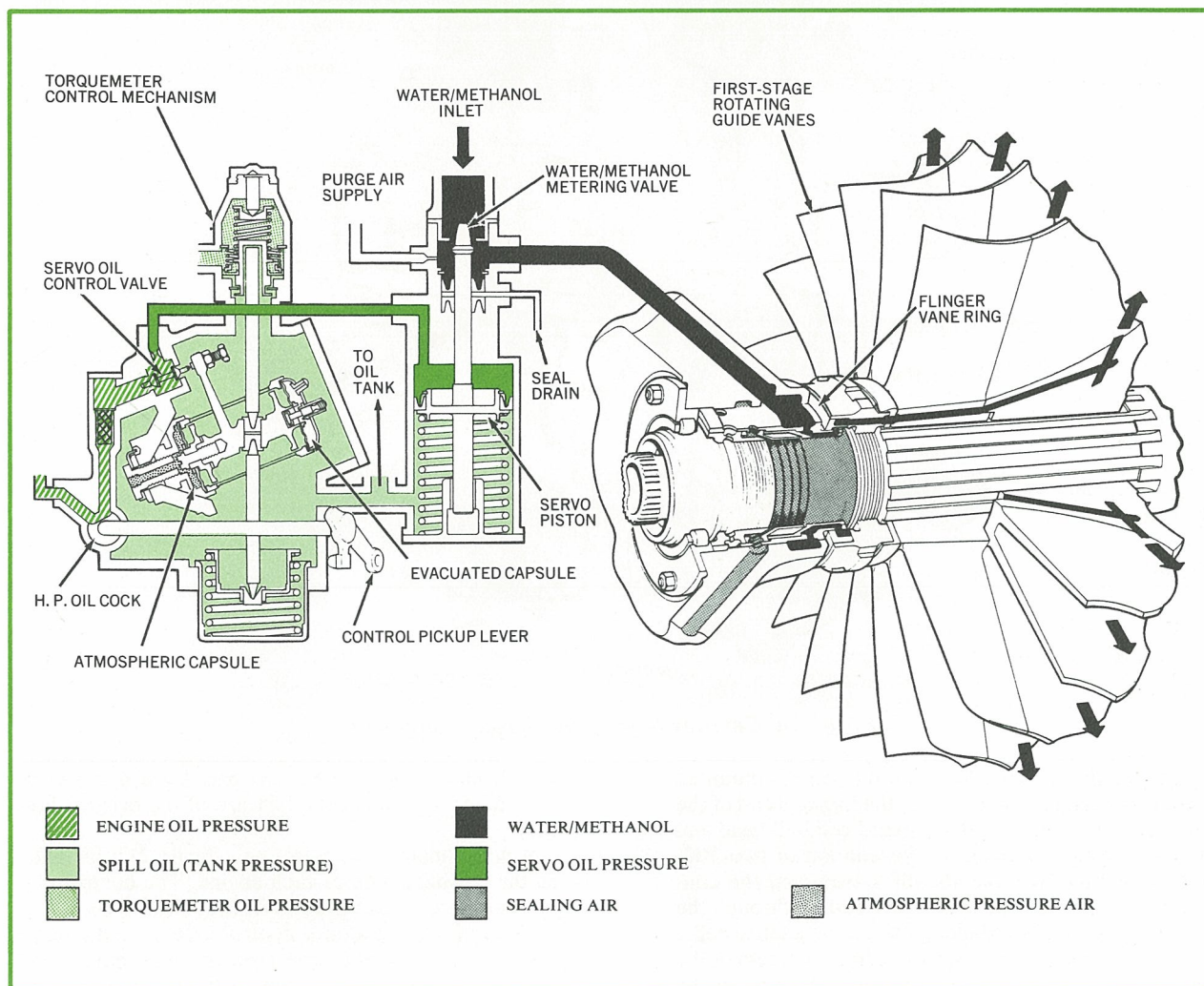


Figure 3. Water/methanol system schematic.

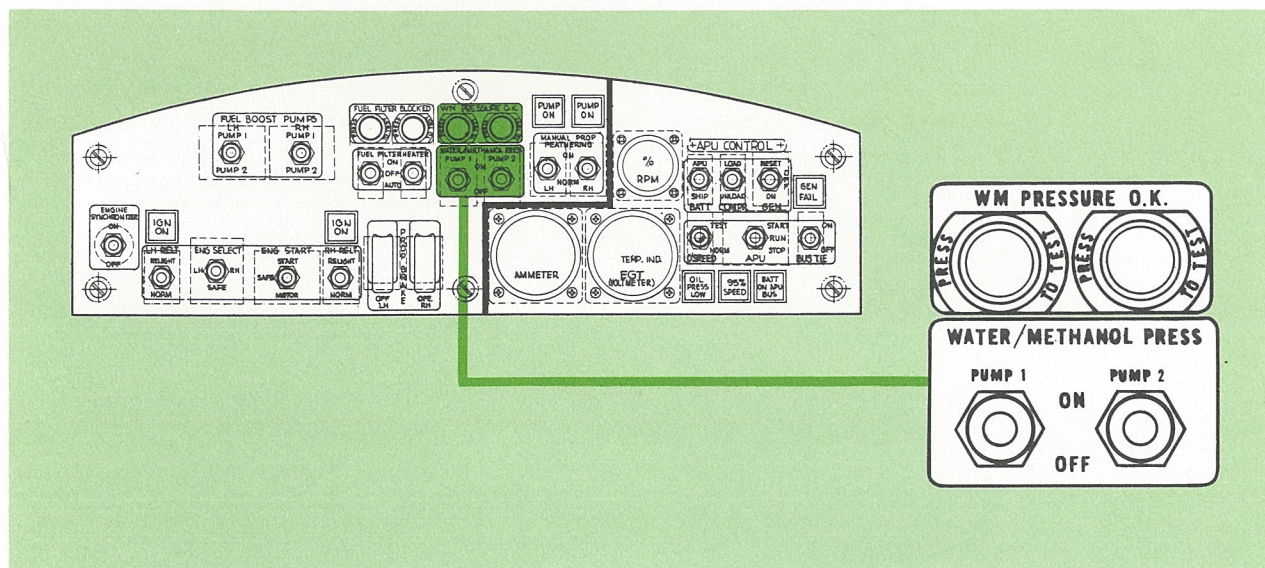


Figure 4. Water/methanol control switches (typical).

At throttle lever positions below the water/methanol 'cut-in' setting, the high-pressure oil cock is closed and, since there is no pressure in the servo system, the metering valve is maintained in the closed position by the loading of the servo piston spring. Hence, there will be no water/methanol flow to the engine, even if the aircraft system is operative.

Prior to takeoff, operation of the water/methanol switches (figure 4) on the overhead switch panel energizes the electric pump and shutoff cock actuator, and water/methanol is supplied to the control unit in readiness for injection into the engine when takeoff is approached on the throttle lever.

As the throttle lever approaches the takeoff position (14,700 to 14,900 rpm), the oil cock is automatically opened by control interconnections, thus permitting high-pressure engine oil to reach the servo control shuttle valve. The servo valve meters engine oil to the top of the springloaded servo piston where the oil pressure overcomes the springloading of the piston and progressively opens the water/methanol metering valve.

Water/methanol is metered to an annulus in the first-stage compressor front bearing housing (figure 5) where it spills from the annulus into a flinger ring on the compressor shaft. Grooves and passages, machined in the shaft and impeller nut, transfer the mixture to orifices in the rotating guide vanes and impeller to be flung outward by centrifugal force.

Fuel flow and selection of rpm and water/methanol are mechanically interconnected through a system of control rods and levers (see figure 6). Full movement of the pilot's power lever results in simultaneous full movement of the engine fuel throttle valve, propeller control unit, rpm selector lever, and the water/methanol control oil valve.

Linkage to the water/methanol unit ensures that when the pilot's lever approaches and reaches the take-off position, the water/methanol oil valve is open; it is closed at all other rpm positions.

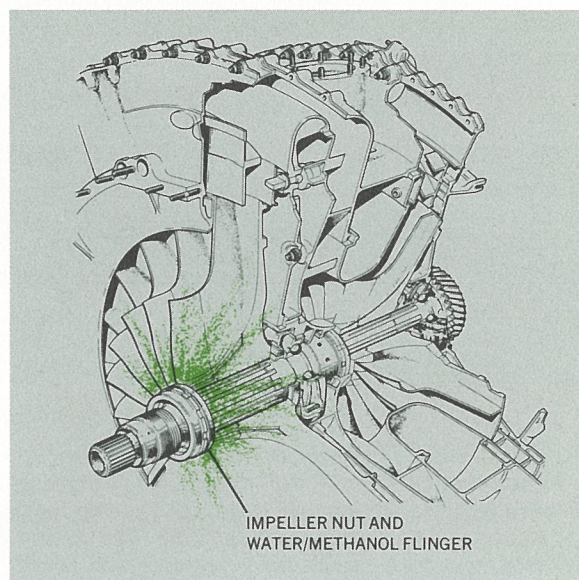


Figure 5. Flow of water/methanol into engine.

On an ISA day at sea level, the forces acting on the capsule stem are so rated that a torquemeter oil pressure equivalent to the water/methanol check pressure is required to bring the control assembly into balance. With a torquemeter pressure equivalent to the dry engine rated power initially supplied to the unit, the forces are out-of-balance and the tappet arm is positioned away from the shuttle valve. Opening of the oil cock allows the oil to force the shuttle valve toward its outer seat; the resultant high servo pressure opens the metering valve. Injection continues to increase engine power and the torque pressure until the control system is balanced, maintaining the shuttle valve in a sensitive position and keeping the metering valve open sufficiently to give a water/methanol flow to maintain sea level boosted power.

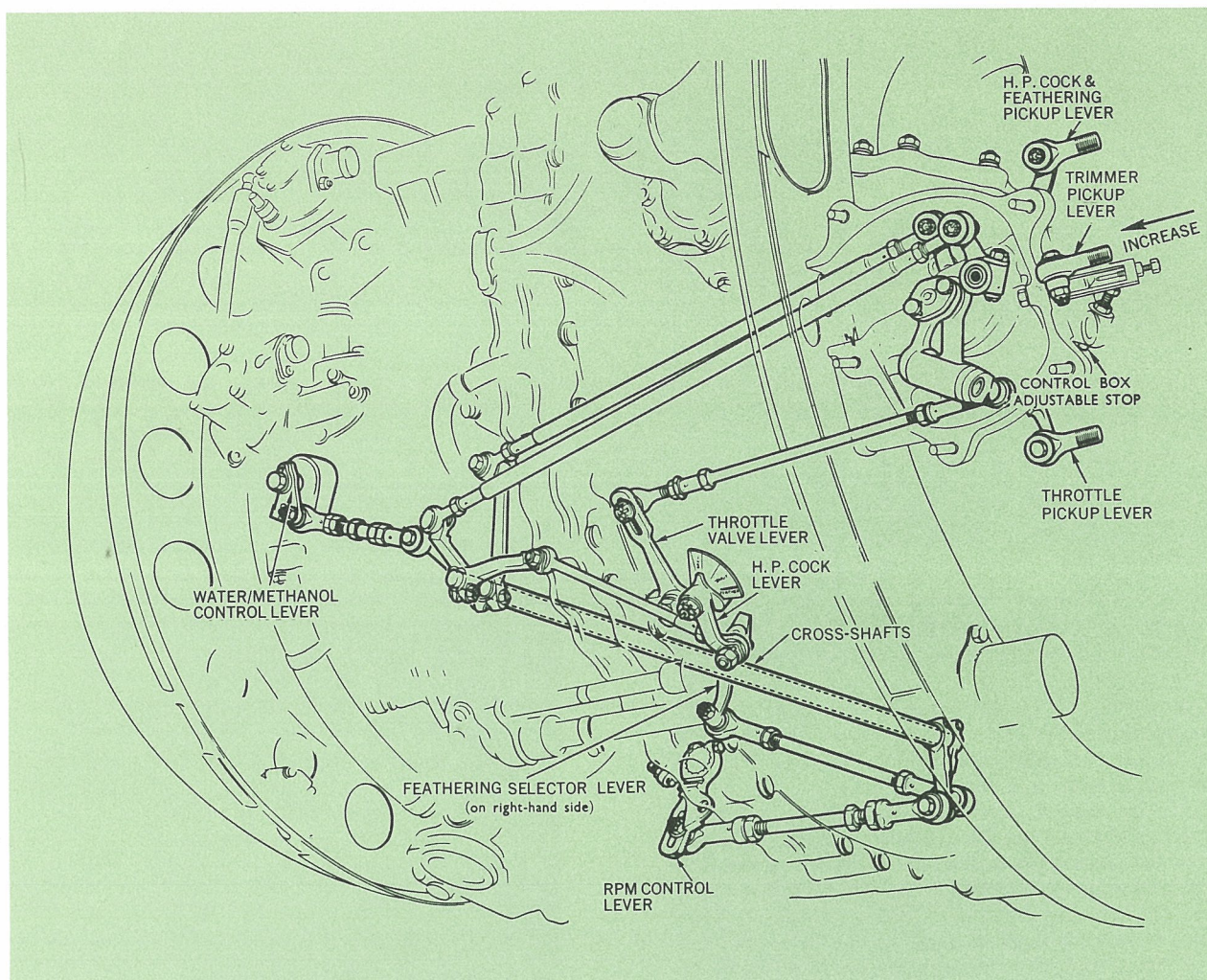


Figure 6. Interconnection of controls to water/methanol supply.

At temperatures above ISA, the engine power and torque pressures are low, causing an even larger out-of-balance force in the control assembly. The control assembly selects a higher servo pressure and hence a higher flow of water/methanol. Equilibrium is reached when this increased flow has restored the torque-meter pressure to maintain the corrected sea level boosted power to the engine. In this condition, the low torque-meter pressure tends to increase servo pressure; however, the pressure in the atmospheric capsule is less than at sea level. The resultant load of the capsule assembly is reduced, causing an out-of-balance force in the control assembly that is equivalent to 6 psi of torque pressure per 1000 feet of altitude, thus tending to reduce servo pressure. The control assembly becomes balanced at a new sensitive position of the shuttle valve. The forces on the capsule stem are thus re-rated with changes in pressure altitude.

At these conditions, torque pressure will be lower than at the ISA condition, and the resultant unbalance will give greater shuttle valve opening, higher servo pressure, and increased water/methanol flow to restore the ISA altitude torque-meter pressure.

To prevent water/methanol flow to the engine in the event of an engine feather, after takeoff, the low torque pressure relay is energized by its respective auto-feather circuit, applying power to the water/methanol shutoff valve to stop flow to the feathered engine (see figure 7).

This automatic feature relieves the pilot of the responsibility of having to stop water/methanol flow to the engine during a critical period of flight.

The system is automatically deactivated if a propeller is manually feathered or the T handle is pulled, both on the ground and in the air.

On the ground, if the right-hand propeller feathers automatically, water/methanol will automatically shut off. If the left-hand propeller automatically feathers, however, the water/methanol for that engine must be manually deactivated.

After takeoff, when the throttle lever is moved from the takeoff position and the metering valve is closed, a continuous supply of air from the first-stage compressor is fed through the engine water/methanol passages to ensure complete drying out of the surfaces, thus preventing corrosion.

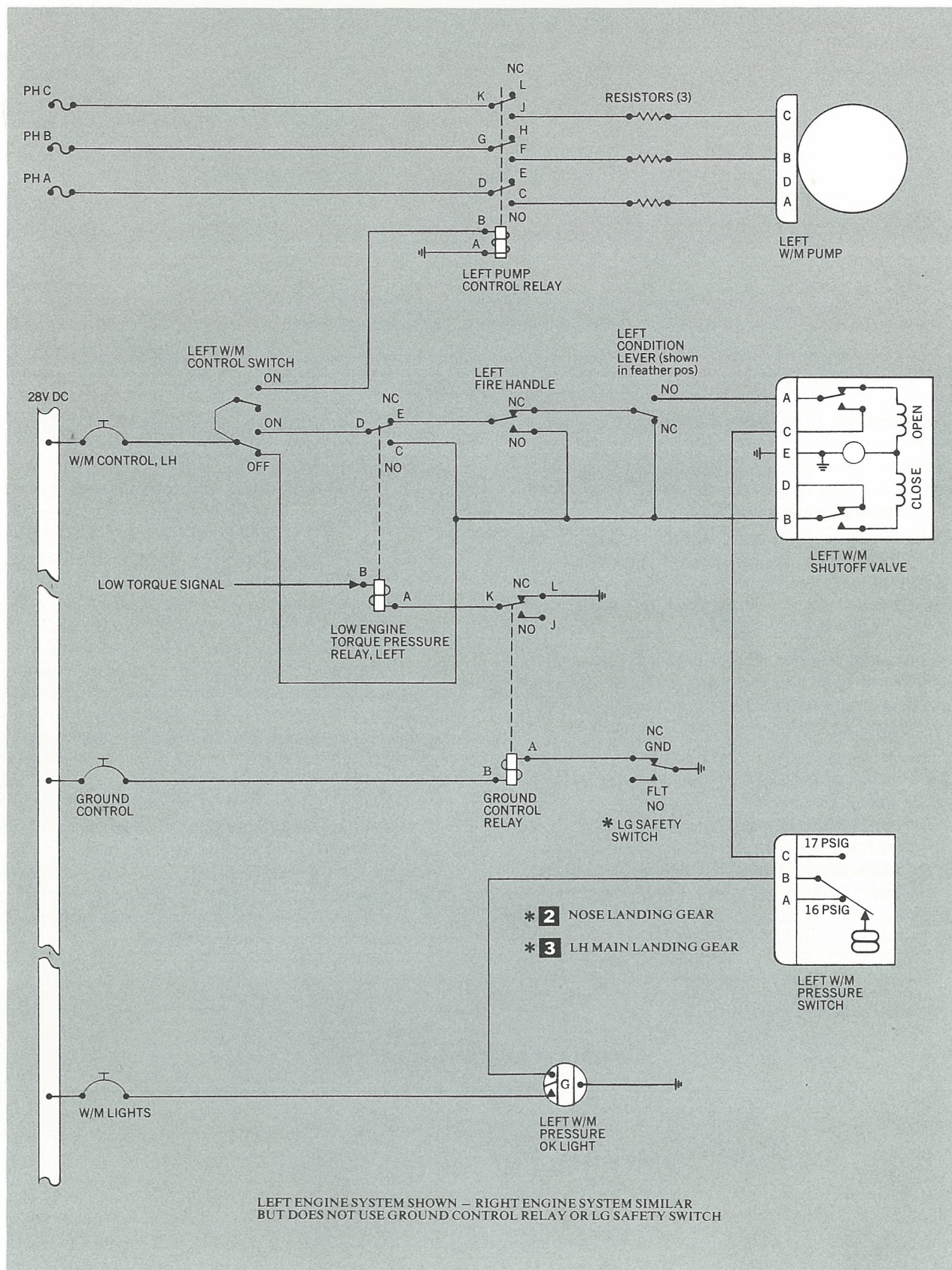


Figure 7. Water/methanol control system schematic.

## Convair Continues Work on Crashworthiness

THE CONVAIR DIVISION of General Dynamics has received its third contract from the Federal Aviation Agency for studies under the FAA's overall program to improve the crashworthiness of commercial transports.

The recently awarded contract, totaling just over \$200,000, calls for design studies and a model structures test program to improve fuselage resistance and chances of passenger survival under crash conditions.

Convair's previous studies in this field included another on airplane structure and one on fuel containment. (See Convair Travelers for November/December 1963 and January/February 1964.)

The program will be divided into two phases. The first, which is to be concluded by April 1967, will be devoted to evaluation of existing and new design concepts to determine methods of improving cabin integrity during crash impact landings. During this phase, simulated fuselage sections, or cylinders, 100 inches long by 100 inches in diameter, will be tested at the structures test laboratory, Convair Harbor Drive Test Site, to

prove design concepts. The cylinders, weighing up to 20,000 pounds, will be drop-tested to buckle the specimens on impact.

In the second phase of the program, scale model fuselages, incorporating promising design concepts, will be evaluated by the FAA at its National Aviation Facilities Experimental Center (NAFEC), Atlantic City, N. J.

The specimens for evaluation by the FAA will be scale model fuselages, 22 feet long with a 4-foot nose cone at each end. These specimens will be impacted at progressively increasing speeds to simulate airplanes making crash landings and skidding over a series of inclined slopes to see which fuselages will hold together and which will break up during the crash and its aftermath.

Structural integrity has long been a feature of Convair-built aircraft. While this experience is a significant advantage in a test program such as this, it does not indicate that past work will necessarily be reapplied; but, it does indicate that Convair is aware of the economic, operational, and installation aspects of crashworthiness as well as the direct safety aspects.

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**GENERAL DYNAMICS**

*Convair Division*

VOLUME XVIII

NUMBER 5

JANUARY/FEBRUARY 1967

# *Convair Traveler*

11 44



*In This Issue: Screw Threads  
Blueprint Numbering System for Convair-Liners  
Engineering Clinic*

VOLUME XVIII NUMBER 5 JANUARY/FEBRUARY 1967

## Convair *Traveler*



In This Issue: Screw Threads  
Blueprint Numbering System for Convair-Liners  
Engineering Clinic

### OUR COVER

Bob Herrmann, photographer, couldn't find a bucket of bolts, so he used this tray of bolts and studs to show the various thread forms standardized within the aircraft industry. Tony Adams is the Artist for this issue.

# Convair *Traveler*

VOLUME XVIII NUMBER 5 JANUARY/FEBRUARY 1967

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# Screw Threads

THERE ARE SEVERAL forms of screw threads, most of which have been standardized within the aircraft industry. The standard thread form adopted for industry is the Unified Thread Form. This standard was established in 1948 by Britain, Canada, and the United States for the purpose of obtaining screw thread interchangeability among these three countries.

The American Standard Thread Form, adopted by the United States, is based on the Unified Thread Form except for certain additional diameters and pitches. The American Standard provides greater fatigue strength and root clearance, easier assembly, and longer life for cutting tools.

The Unified Thread Form has substantially the same thread as the American National threads (NC and NF); they are, as a rule, mechanically interchangeable. The principle differences between the two systems are in the application of allowances; in the variation of tolerances with size; in the difference in amount of pitch diameter tolerance on external and internal threads; and differences in thread designations.

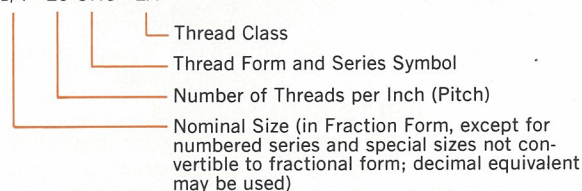
There are three basic classes of the Unified Thread Form, classes 2 and 3 being the standard for use in the aircraft industry (see Table I). The principle differences between American National and Unified are in Class 3 threads, in the distribution of tolerances between the external and internal threads. In the American National thread, the pitch diameter tolerances of external threads of the same size are equal. Under the Unified system, this tolerance is 30 percent greater on the internal thread than on the external thread. In addition to a similar difference in tolerancing, Class 2A and 2B Unified thread dimensions provide an allowance between maximum external and minimum internal threads, which are not provided by American National Class 2.

The Unified standard can be identified by the letter "U" in the thread series symbol, which is an indication that the part is common to Canadian, British, and

American standards. Those without the "U" are American Standard only.

See Table II for thread series symbols and the following diagram for basic thread designation.

1/4 - 20 UNC - 2A


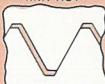
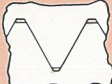

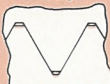


The Unified Thread Form permits, but does not require, rounding of the roots of external and internal threads (see figure 1). Threads designed to withstand severe tension fatigue loading may have rounded roots specified within the limits of the Unified Form. For example, the thread of bolts (MS20004 through MS20020) are required by procurement specification MIL-B-7838 to have roots rounded within specified radius limits which can be achieved within the Unified Thread Form envelope. External threads conforming to the Unified Thread Form, except for root radii larger than those possible within the Unified minor diameter limits, are specified by MIL-S-8879, *Screw Threads Controlled Radius Root with Increased Minor Diameter, General Specification for*, revised 1965.

External threads with maximum root radius conforming to this specification would have some interference with the crests of internal threads of minimum minor diameter permitted by the Unified form. Although the probability of such interference is small, MIL-S-8879 provides for complete avoidance by including increased minor diameter limits for internal threads.

Because tolerances for external threads differ from those for internal threads under Unified Standards, the letter "A" is used in the thread symbol to denote an

TABLE I CLASSES OF THREAD FITS

| CLASS | EXAMPLE   |  |   | DEFINITION  |
|-------|---|--|---|---|
| 2     | <div>MAX NUT</div>  <div>MIN BOLT</div> <div>UNIFIED AND AMERICAN NATIONAL SERIES</div> <div>LOOSEST CONDITION</div> | <div>MIN NUT</div>  <div>MAX BOLT</div> <div>UNIFIED SERIES</div>   | <div>MIN NUT</div>  <div>MAX BOLT</div> <div>AMERICAN NATIONAL SERIES</div>  | <p>The Class 2 fit is the most widely employed fit in the manufacture of screw threads. Its usage in aircraft and engine manufacture is limited to threaded fasteners of a size less than No. 10. The standard to which the thread is made determines whether or not an allowance will exist at the tightest condition.</p> |
|       | TIGHTEST CONDITION  |  |   |   |
| 3     | <div>MAX NUT</div>  <div>MIN BOLT</div> <div>UNIFIED AND AMERICAN NATIONAL SERIES</div> <div>LOOSEST CONDITION</div> | <div>MIN NUT</div>  <div>MAX BOLT</div> <div>UNIFIED AND AMERICAN NATIONAL SERIES</div> <div>TIGHTEST CONDITION</div> | <p>The Class 3 fit provides the highest grade of interchangeable screw thread work. Tolerances are smaller than those for Class 2. This class of fit is to be specified for general aircraft usage.</p> |   |

external thread; the letter "B" is used to denote an internal thread. The letter "U" in the thread symbol identifies Unified Thread sizes. Omission of the letter "U" but retention of the letters "A" and "B" in the thread symbol indicate the thread conforms to the principles on which the Unified Thread is based. Tolerances for the American Standard Form apply when the letters "U", "A", or "B" do NOT appear in the thread symbol.

When internal threads are designated as UNJF-3B or UNJC-3B, or as UNF-3B or UNC-3B/MIL-S-8879, the effect is merely to increase the minor diameter slightly to make them completely acceptable for mating with Unified Form external threads.

### BOLTS AND SCREWS

Standard bolts and screws with hexagon or Phillips recessed heads are generally used in structural applications: 100° flush head screws are used where protruding heads are not acceptable. Protruding head (round brazier, or pan) screws with Phillips recesses are used where space precludes use of hexagon head

bolts or the qualities of bolts are not required. Hexagon head bolts are generally used where space permits because they can be tightened or removed more easily. Bolts designed and manufactured to withstand high tension loads, especially when subjected to fatigue loading, usually have internal wrenching heads, such as MS20004 through MS20020 series, or double-hexagon heads with extended washer faces.

Types of standard bolts and screws, their materials and uses are given in Table III.

If a special bolt is required, it should be made from a standard bolt, if possible. If it is not possible, the following specifications should apply:

Threads must conform to Unified Series as identified in Specification MIL-S-7742 and National Bureau of Standards Handbook H-28.

No. 8 size bolt threads and smaller must be of the UNC (Unified) series while No. 10 and larger must be the UNF (Unified National Fine) series. In all cases, threads are to conform to the Unified Thread formulas.

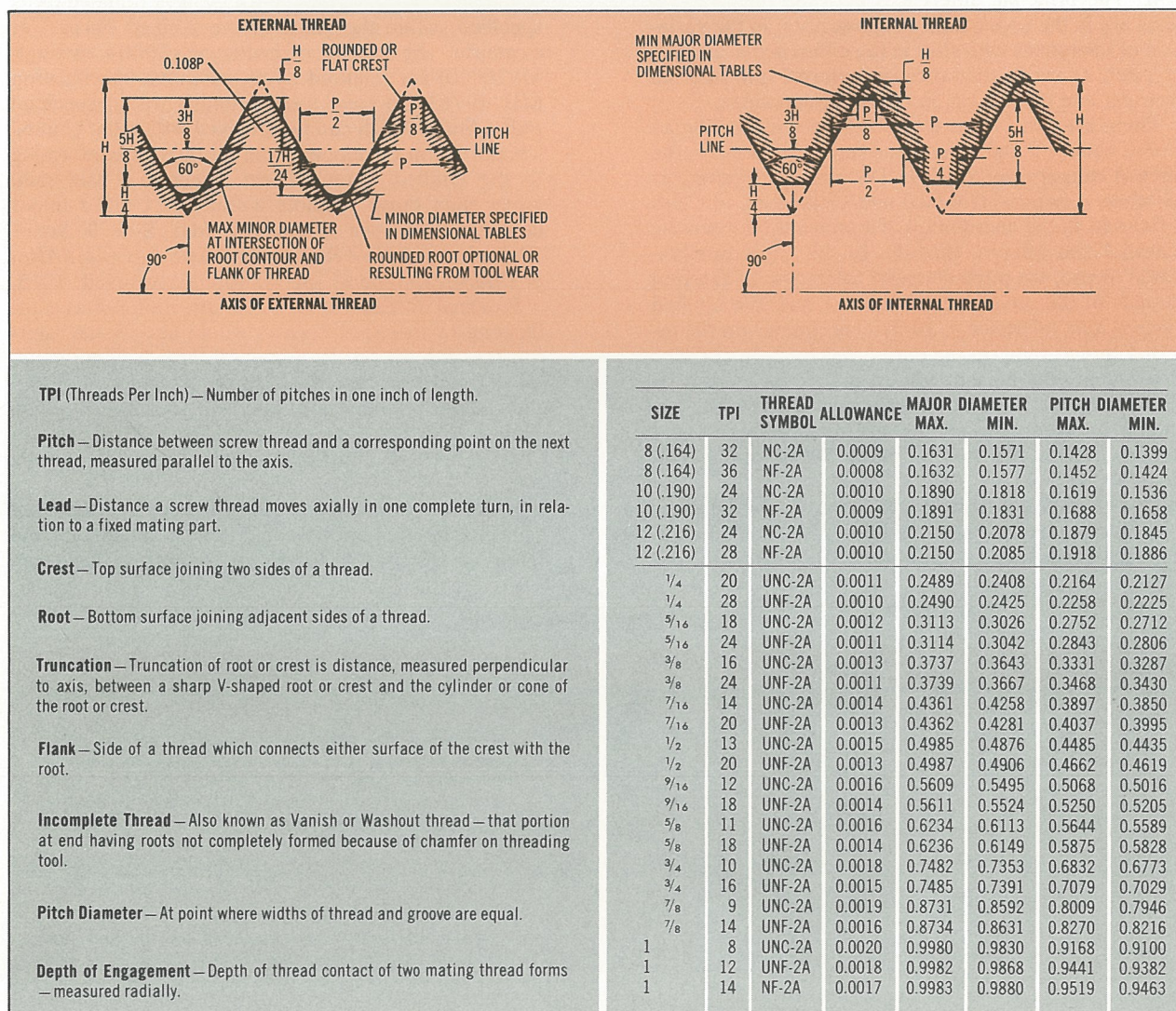


Figure 1. Screw thread designs.

TABLE II THREAD SERIES

| THREAD SERIES                       | *SYMBOL                            | USAGE   |
|-------------------------------------|------------------------------------|---|
| American National Coarse Thread     | NC                                 | Threaded fasteners of a diameter less than No. 10, or where fairly rapid engagement is desired.   |
| Unified Coarse Thread               | NC-A<br>NC-B<br>UNC-A<br>UNC-B     |   |
| American National Fine Thread       | NF                                 | General application for aircraft fastenings 1-1/2 inch and less in diameter.  |
| Unified Fine Thread                 | NF-A<br>NF-B<br>UNF-A<br>UNF-B     |   |
| American National Extra Fine Thread | NEF                                | Threads on thin-walled tubing or where maximum number of threads in a given length is required. Avoid if possible. For use on parts 1/4 diameter to 1-11/16 diameter. |
| Unified Extra Fine Thread           | NEF-A<br>NEF-B<br>UNEF-A<br>UNEF-B |   |
| American National 12-Thread         | 12N                                | Compares to NF threads in large diameter. Use whenever possible for thin-wall parts having a diameter greater than 1.06 inches.                                       |
| Unified 12-Thread                   | 12N-A<br>12N-B<br>12UN-A<br>12UN-B |   |
| American National 16-Thread         | 16N                                | Recommended for threaded adjusting collars of large diameter or for any application in which a fine adjustment is required.   |
| Unified 16-Thread                   | 16N<br>16N-B<br>16UN-A<br>16UN-B   |   |

\*Thread sizes which are recognized as Unified are characterized by the letter "U" in the symbol, such as "UNC." All other sizes omit the "U" in the symbol but retain the "A" and "B" designations to indicate that the thread conforms to the principles on which the Unified Thread is based. Tolerances for the American National form apply when the letters "U", "A", or "B" do not appear in the thread symbol.

The Rolls-Royce Dart engine and Dowty Rotol propeller installations use the Unified Thread form. Many of the stud installations for the Dart engine use the metric thread for installation in the engine, and the Unified Thread form for attachment of accessories and equipment. If a Unified form nut is not available for installation on the Unified Thread form stud, an AN nut of the proper size may be used. The only problems arising in a substitution of this type would be in a few special cases where a very close tolerance is to be held. When an AN and Unified Thread are mixed, the resulting tolerance, or fit, is not always as good as would result from unmixed parts and will affect torque values to some degree but not enough to pose a serious problem.

When installing an AN nut on a Unified Thread form, the nut should be wrenched on to "wipe" the threads; then removed and reinstalled with the proper torque value.

All Unified Thread parts can be identified by turners, circles, or washer facings. Figure 2 which illustrates identification points, will help maintenance personnel to recognize and become familiar with the Unified Thread form on the Dart engine.

Nuts are selected on considerations relative to type of bolt, or stud; screw material used; galling characteristics of the metal combination; temperature limitations; dissimilar metal corrosion characteristics; and design application. As a general rule, nuts are selected of the same material, or in the same or similar metal group.

There are certain measures and precautions to be taken when installing any nut.

Chamfered bolts and screws are to be of sufficient length to permit the full chamfer to extend through the nut. Flat-end bolts and screws are to extend at least 1/32-inch through the nut. Maximum material thickness is to be used when calculating bolt and screw length.

The threaded portion of bolts and screws is not to be used in bearing to take shear loads.

Special nuts, which depend on friction for their anchorage and torsional rigidity, such as clinch nuts, spline nuts, single rivet nut plates and similar devices, are not to be used on structural components. They are to be used for mounting instruments and equipment of a similar nature.

Cadmium-plated alloy steel nuts are not to be used where temperatures exceed 450°F (232.2°C).

Self-locking nuts are not to be used at joints where relative motion of parts would tend to loosen the nuts. They may be used with anti-friction bearings and control pulleys, provided the inner race of the bearing is clamped to the supporting structure by the nut and bolt.

Nuts requiring removal are to be locked by use of a self-locking type nut, safety wire, jam nut, bent tab washer, or castellated nut with cotter pin.

Anchor plate nuts are not to be used where both ends of the screw or bolt are accessible. When using spring type nuts with sheet metal screws, only coarse thread series screws are used. These nuts are not used in locations subject to severe vibration.

Self-locking elastic stop nuts of the 10-32 and 1/4-28 sizes are to be used only with bolts or screws that have not been drilled for cotter pins.

Solid steel locknuts may be used on bolts or screws with drilled shank.

The types of nuts in general use on aircraft are tabulated in Table IV, pages 7 and 8.

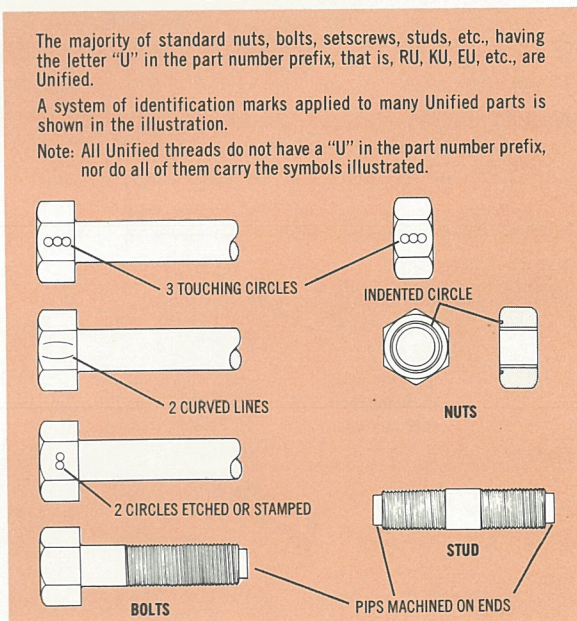
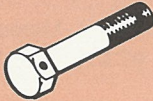

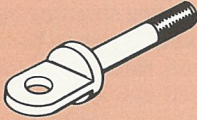









Figure 2. Identification of parts featuring Unified Threads.

TABLE III BOLT TYPES

| PART NO.  | TYPE   | MATERIAL                      | REMARKS  |
|---|--|-------------------------------|--|
| AN3 through AN20  |  <p>Hex head with shank and head drilled or undrilled</p>     | CRES Steel,<br>Non CRES Steel | <ol style="list-style-type: none"> <li>1. General structural application with drilled or reamed holes.</li> <li>2. Can be safetied through head when hole is specified.</li> </ol>   |
| AN21 through AN36   |  <p>Clevis-slotted head; shank drilled or undrilled</p>       | Steel                         | <ol style="list-style-type: none"> <li>1. Used where minimum head clearance is necessary, or slightly smaller shank diameter than AN3 series is required; also used where shearing stresses are present, such as for mechanical pins in control systems.</li> <li>2. Used in extremely close tolerance holes.</li> <li>3. <b>Do Not use in tension</b>; the tension allowable is approximately 1/2 that of standard hex head bolts.</li> <li>4. When used, mating nut must be accessible to a torque wrench.</li> <li>5. Avoid use whenever possible.</li> </ol> |
| AN42 through AN49   |  <p>Eyebolt; shank drilled or undrilled</p>                   | Steel                         | <ol style="list-style-type: none"> <li>1. May be used with clevises, turnbuckle forks, cable, shackles, etc. or any other application requiring an eyebolt.</li> </ol>   |
| AN173 through AN186   |  <p>Close tolerance hex head; shank drilled or undrilled</p> | Non-CRES Steel,<br>CRES steel | <ol style="list-style-type: none"> <li>1. Used when close fit between bolts and structure is required.</li> <li>2. Used in reamed holes only.</li> </ol>   |
| NAS 144 through NAS 156;<br>NAS 495;<br>MS20004 through MS20024 |  <p>Internal wrenching; head drilled or undrilled</p>       | Steel                         | <ol style="list-style-type: none"> <li>1. Used for high tension loads or where there is insufficient wrench clearance for hex head type.</li> <li>2. Has internal wrenching recess.</li> <li>3. Bolt hole must be countersunk or NAS 143 (or MS20002) washer must be used to offset fillet radius.</li> <li>4. CVAC NU32 nut must be used with these bolts.</li> <li>5. Avoid use whenever possible because of cost.</li> <li>6. Used on early Convair-Liner aircraft.</li> </ol>  |
| NAS 334 through NAS 340   |  <p>100° flat head, close-tolerance, high strength</p>      | Steel                         | <ol style="list-style-type: none"> <li>1. Used where high strength, close tolerance and flush surface is required.</li> <li>2. Used for clearance purposes or where wrench clearance is critical for hex head type.</li> <li>3. Used where joints are subjected to severe load reversals and vibration.</li> <li>4. Requires countersink application and should be avoided whenever possible.</li> </ol>   |
| AN428   |  <p>Crowned hex head, adjusting</p>                         | Steel                         | <ol style="list-style-type: none"> <li>1. Used where adjustment of bolt may be required such as for stops, etc.</li> <li>2. <b>Do not use for structural applications.</b></li> </ol>  |

**TABLE III BOLT TYPES** (Continued)

| PART NO. | TYPE  | MATERIAL | REMARKS  |
|----------|---|----------|--|
| NAS 464  |  <p>Hex head, close tolerance, shear; drilled or undrilled shank</p> | Steel    | <ol style="list-style-type: none"> <li>1. Used for special close tolerance applications where high shear strength is required.</li> <li>2. Requires reamed hole.</li> <li>3. Do not use where more common bolts will suffice.</li> <li>4. Used for control surface hinge points to reduce play.</li> <li>5. Used with drilled holes for cotter pin locking.</li> <li>6. Used on early Convair-Liner aircraft.</li> </ol> |
| NAS 1103 |  <p>Close tolerance, hex head</p>                                    | Steel    | <ol style="list-style-type: none"> <li>1. Used in close tolerance applications.</li> <li>2. Used in landing gear uplock levers and torque arm brackets.</li> <li>3. Cotter pin hole in shank.</li> </ol>   |
| NAS 1203 |  <p>100° close tolerance head and shank</p>                          | Steel    | <ol style="list-style-type: none"> <li>1. Phillips recess.</li> <li>2. Cotter pin hole in shank.</li> <li>3. Used for attaching access plates, piano hinges, interior lining and partitions.</li> </ol>  |

**TABLE IV TYPES OF NUTS**






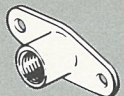







| PART NO. | TYPE  | SIZE                   | MATERIAL  | REMARKS  |
|----------|---|------------------------|---|--|
| AN315    |  <p>Plain airframe fine thread — LH and RH</p> | 10-32 through 1-1/4-12 | Steel<br>CRES Steel<br>Al Alloy   | <ol style="list-style-type: none"> <li>1. Requires either a check nut or washer to prevent loosening.</li> </ol>   |
| AN316    |  <p>Check nut, fine thread</p>                 | 1/4-28 through 1-14    | Steel<br>CRES Steel   | <ol style="list-style-type: none"> <li>1. Used as locknut for plain nuts such as AN315, AN335, AN340, and AN345.</li> <li>2. For sizes smaller than 1/4, use AN315 as check nut.</li> <li>3. Sometimes used on set screws and threaded rod ends.</li> </ol>                          |
| AN320    |  <p>Castle nut, shear; fine thread</p>         | 10-32 through 1-1/4-12 | Steel   | <ol style="list-style-type: none"> <li>1. Used for shear loads where mating parts have relative motion.</li> <li>2. Must be used with drilled shank bolts.</li> </ol>  |
| AN340    |  <p>Light hex nut, coarse thread</p>           | 4-40 through 8-32      | Carbon steel<br>com'l grade brass<br>com'l grade al alloy<br>CRES steel | <ol style="list-style-type: none"> <li>1. Used for miscellaneous applications, mostly nonstructural.</li> <li>2. Requires either a check nut or lockwasher, or bolt must be peened to prevent loosening.</li> <li>3. Do not use peening method if nut is to be removable.</li> </ol> |

TABLE IV TYPES OF NUTS (Continued)

| PART NO.                       | TYPE  | SIZE                          | MATERIAL  | REMARKS  |
|--------------------------------|---|-------------------------------|---|--|
| AN350                          | <br>Wing nut<br>UNF-2 thread   | 6-32<br>through<br>1/2-20     | Steel<br>Brass  | 1. Used for non-structural applications where finger-tightness is satisfactory and quick removal is necessary.<br>2. Can be safetied with wire through hole in wing.   |
| AN362                          | <br>Self-locking plate nut—<br>non-countersink<br>550°F              | 6-32<br>through<br>3/8-24     | Steel<br>CRES Steel   | 1. Used for most self-locking medium temperature applications where plate nut is required.   |
| AN363                          | <br>Self-locking nut, 550°F  | 10-32<br>through<br>3/4-16    | Steel<br>CRES Steel<br>Copper Base Alloy                      | 1. Used for most self-locking medium temperature applications. For sizes larger than 3/8 only.<br>2. <b>Do not use if parts have relative motion.</b><br>3. For 3/8 and smaller, use MS21042.  |
| AN366                          | <br>Non-C'Sink plate nut,<br>250°F                                   |                               | Steel   | 1. Used for most self-locking low-temperature applications where plate nut is required.  |
| MS20341                        | <br>Hex electrical<br>NC and UNF<br>threads                         | 4-40 through<br>5/8-18        | Brass, Spec<br>QQ-B-611                                       | 1. Used for electrical bonding and miscellaneous applications.<br>2. Not used structurally.  |
| MS20364                        | <br>Self-locking thin nut, 250°F                                   | 3/8-24<br>through<br>1-1/4-12 | Steel   | 1. Used for most self-locking medium-temperature applications where shear nut is desirable.<br>2. Used only for sizes larger than 3/8; for 3/8 and smaller, use MS21042.<br>3. Not used if parts have relative motion.                                     |
| MS20365                        | <br>Self-locking nut, 250°F  | 4-40<br>through<br>1-1/4-12   | Steel   | 1. Used for most self-locking low temperature applications in tension. For sizes larger than 3/4 only in steel; all sizes in al alloy. For 3/8 and smaller, use MS21042; for 7/16 through 3/4, use AN363.<br>2. Not used if parts have relative motion.    |
| NAS 509                        | <br>Drilled jam nut  | 1/4-28<br>through<br>2-1/4-12 | Alloy Steel<br>150,000 psi<br>cad plate                       | 1. Used with NAS 559 key for locking rod ends.<br>2. Temperature range — 100° to 500°F.  |
| NAS 1291<br>MS21042<br>MS21043 | <br>Self-locking hex nut; low height, lightweight<br>450° to 800°F | 2-56<br>through<br>3/8-24     | Alloy steel<br>160,000 psi;<br>A286 CRES steel<br>125,000 psi | 1. Approved hex self-locking nut in sizes listed for use with alloy steel fasteners up to 160,000 psi, and CRES fasteners up to 140,000 psi.<br>2. Replaces AN363, AN364, AN365 and NAS 679 nuts of like sizes; used on early Convair-Liner type aircraft. |

# Blueprint Numbering System for Convair-Liners

THE BLUEPRINT is designed to furnish instruction for fabrication, installation, inspection, training, maintenance, and engineering. It is, in effect, an all-purpose aircraft manual.

Drawing numbering systems vary with the manufacturers. Convair's numbering system for Convair-

Liners, which is somewhat different from the jet airliner system, provides information for obtaining system, structure, and installation drawing numbers. These numbers may be obtained through a composition of figures derived from the following drawing number breakdown.

|  |   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
|--|---|---|---------------------------------------|-----------------------------|---------------------|-----------------------------------|-------------------------|--------------------------------|----------------|---|-----------------------------|---------|--------------|------------------------|--------------|--------------------------|--------------|-------------|-----------------------|------------------------|----------------|-----------|----------------|-----------|--|
| <p>XXX XX XX X XX</p> <p>Supplemental Numbers<br/>Supplement of Functional Number<br/>Functional Group and Version<br/>Component Group (Area)<br/>Model 240 or 340</p>   |   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| <p>EXAMPLE</p> <p>340 -31 10 7 68</p> <p>68th Drawing Listed for Fuselage Structure<br/>Fitting<br/>Structure - All Versions<br/>Fuselage Nose Section<br/>Model 340</p>   |   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| <p>SUPPLEMENTAL NUMBERS</p> <p>Example: - Fuselage Structure - Longerons (340-3010199)</p> <p>XXX 3X 1 X XXX</p> <p>Supplement No.<br/>Version Code<br/>30 General<br/>31 Nose Section<br/>33 Intermediate Section<br/>35 Aft Section</p>  |   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| <p>SUPPLEMENT NUMBERS</p> <table> <tr> <td>000-009 Main Assemblies and Installations</td><td>500-599 Floors, Walkways and Supports</td></tr> <tr> <td>100-199 Longerons and Beams</td><td>600-699 Doors (All)</td></tr> <tr> <td>200-299 Bulkheads and Belt Frames</td><td>700-799 Fittings</td></tr> <tr> <td>300-399 Windows and Enclosures</td><td>800-899 Open</td></tr> <tr> <td>400-499 Plating Stringers and Stringer Panels</td><td>900-999 Miscellaneous</td></tr> </table> |   | 000-009 Main Assemblies and Installations | 500-599 Floors, Walkways and Supports | 100-199 Longerons and Beams | 600-699 Doors (All) | 200-299 Bulkheads and Belt Frames | 700-799 Fittings        | 300-399 Windows and Enclosures | 800-899 Open   | 400-499 Plating Stringers and Stringer Panels | 900-999 Miscellaneous       |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 000-009 Main Assemblies and Installations  | 500-599 Floors, Walkways and Supports   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 100-199 Longerons and Beams  | 600-699 Doors (All)   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 200-299 Bulkheads and Belt Frames  | 700-799 Fittings  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 300-399 Windows and Enclosures   | 800-899 Open  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 400-499 Plating Stringers and Stringer Panels  | 900-999 Miscellaneous   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| <p>COMMON VERSION CODE</p> <p>0 All except as noted below<br/>5 340-64<br/>7 340-70, 71, 72</p>  |   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| <p>FUNCTIONAL GROUP</p> <p>0 General<br/>1 Structure<br/>2 Power Plant<br/>3 Instruments and Radio<br/>4 Surface Controls<br/>5 Operating Mechanism<br/>6 Electrical<br/>8 Hydraulic or Pneumatic<br/>9 Furnishings</p>  | <p>COMPONENT GROUP</p> <table> <tr> <td>00 General</td><td>30 Fuselage (General)</td></tr> <tr> <td>10 Wing (General)</td><td>31 Nose Section</td></tr> <tr> <td>14 Tip</td><td>33 Intermediate Section</td></tr> <tr> <td>16 Central Section</td><td>35 Aft Section</td></tr> <tr> <td>17 Aileron</td><td>50 Alighting Gear (General)</td></tr> <tr> <td>18 Flap</td><td>51 Main Gear</td></tr> <tr> <td>20 Empennage (General)</td><td>52 Nose Gear</td></tr> <tr> <td>21 Horizontal Stabilizer</td><td>53 Tail Gear</td></tr> <tr> <td>22 Elevator</td><td>60 Nacelles (General)</td></tr> <tr> <td>23 Vertical Stabilizer</td><td>61 Fwd Section</td></tr> <tr> <td>25 Dorsal</td><td>62 Aft Section</td></tr> <tr> <td>26 Rudder</td><td></td></tr> </table> | 00 General                                | 30 Fuselage (General)                 | 10 Wing (General)           | 31 Nose Section     | 14 Tip                            | 33 Intermediate Section | 16 Central Section             | 35 Aft Section | 17 Aileron                                    | 50 Alighting Gear (General) | 18 Flap | 51 Main Gear | 20 Empennage (General) | 52 Nose Gear | 21 Horizontal Stabilizer | 53 Tail Gear | 22 Elevator | 60 Nacelles (General) | 23 Vertical Stabilizer | 61 Fwd Section | 25 Dorsal | 62 Aft Section | 26 Rudder |  |
| 00 General   | 30 Fuselage (General)   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 10 Wing (General)  | 31 Nose Section   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 14 Tip   | 33 Intermediate Section   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 16 Central Section   | 35 Aft Section  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 17 Aileron   | 50 Alighting Gear (General)   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 18 Flap  | 51 Main Gear  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 20 Empennage (General)   | 52 Nose Gear  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 21 Horizontal Stabilizer   | 53 Tail Gear  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 22 Elevator  | 60 Nacelles (General)   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 23 Vertical Stabilizer   | 61 Fwd Section  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 25 Dorsal  | 62 Aft Section  |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |
| 26 Rudder  |   |   |                                       |                             |                     |                                   |                         |                                |                |   |                             |         |              |                        |              |                          |              |             |                       |                        |                |           |                |           |  |

## SKYDROL 500B

Approximately two and one-half years ago, the commercial aviation industry sought the assistance of Monsanto Company in attempting to find the cause of metal erosion problems that were affecting the performance of aircraft hydraulic control valves. This phenomenon was manifesting itself in the form of control problems due primarily to high internal leakage within the hydraulic system.

Monsanto technicians together with those of the aircraft industry determined that a major contributing cause of this metal removal was cavitation. Once the problem was identified, Monsanto undertook to determine the basic cause of the cavitation as well as to seek a solution. Detailed studies were made into the basic sciences relating to cavitation.

The first phase of the research effort related to the utilization of an ultrasonic probe test method aimed at determining the effect of cavitation on different fluids and different metal structures. After more than 2500 tests, Skydrol 500B was found to be the best solution.

To further verify the qualities of Skydrol 500B, an orifice testing device was designed, which simulated fluid flow behavior at the full 3000 psi. By varying orifice geometry and dimensions, together with other control factors, such as pressure drops, it was found that Skydrol 500B fluid was appreciably better in cavitation-damage-resistance than Skydrol 500A.

Based on these factors and on analyses of cavitation-damaged valves sent in by commercial airlines around the world, Monsanto recommends the use of 500B in aircraft hydraulic systems as a step toward totally solving the hydraulic control valve cavitation damage problem.

Convair concurs with Monsanto recommendations.

Skydrol 500A and 500B are alike in appearance—both are clear purple—but moisture content of Skydrol 500B has been increased to 0.44% by weight as compared to 0.20 maximum of Skydrol 500A. The fluids may be intermixed.

## FUEL LEAKAGE AT DOME NUTS

Convair 880/880M/990

Fuel leakage at the dome nuts on the wing upper skin lower surface has been reported. Location of the dome nuts makes possible the trapping of any water which may pass the head and thread of the attachment screws. Following are recommendations for providing protection in this area.

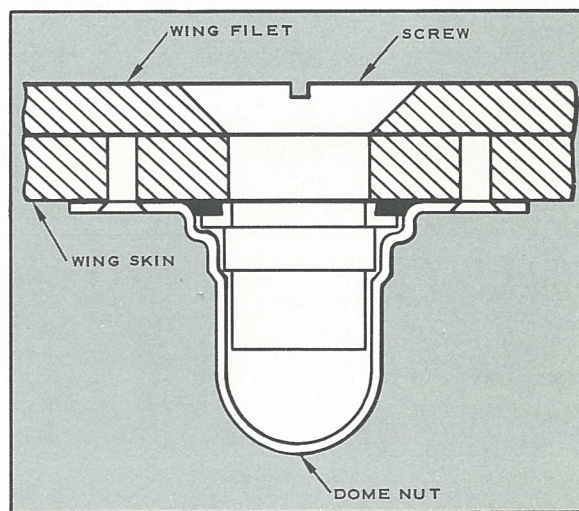
The nut domes are steel, cadmium-plated. In addition, the exteriors are coated with EC776. Coating the interior with EC776 for units installed with the opening upward would be in order. In service, this could be done by putting several drops of EC776 in each opening and then assuring distribution by directing a jet of air into the opening. Any accumulated debris should be blown out prior to treatment.

Putting in several drops of oil or other corrosion inhibiting liquid and blowing out to assure distribution and removal of excess fluid would provide protection to dome nut shells which have been attacked by corrosion.

Dome nuts which have been penetrated by corrosion could be sealed and retained in service by overcoating the shell exterior with EC 1293 at tank over-

haul. It should be assured that the dome interior is not overfilled while coating the exterior.

The foregoing procedures would at least provide temporary protection and might well protect for the full life of the airplane.



## FUEL CONTAINMENT CAPABILITIES OF 600/640

Containment capability of the fuel tanks on Convair 600/640 aircraft, using JP4 or kerosene fuels, is as good as that on the Convair-Liner aircraft using aviation gasoline.

The 340/440 aircraft achieve fuel tank sealing by means of a thin layer of Fairprene (synthetic rubber) sheet used between faying surfaces of all structural members of the tank. Upon contact with fuel, the Fairprene swells a certain amount and forms a very effective seal.

Reaction of Fairprene to JP4 is slightly greater than it is to gasoline; hence, no fuel leakage problems are expected from this source. This has been verified by actual service experience of several turbine powered 340 (640) aircraft.

One item that must be considered when using kerosene is frequency of servicing fuel tank drains. Turbine fuels are hygroscopic, tending to absorb moisture. Also, since the specific gravity of turbine fuel is nearer to water than aviation gasolines, the water tends to remain in suspension and settle out more slowly. This combination of factors makes it possible to introduce more water into the fuel tanks than is the case with gasoline.

To prevent accumulation of water, tank drains must be serviced more frequently. Draining on a daily basis is suggested at the beginning of operations and continuing until experience indicates a different frequency may be used.

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## WATER/METHANOL COUPLINGS

### Installation Procedures

#### Convair 600/640

Proper installation of W/M couplings on Convair 600/640 aircraft should assure five years serviceability before it will be necessary to dismantle the connector and examine the seal.

Following are vendor part numbers that apply to the W/M coupling, P/N FRS595F1.

|                              |        |
|------------------------------|--------|
| Pipe Connector               | *595/F |
| Locking Circlip              | 180/F  |
| Outer Sleeve                 | 134/F  |
| Inner Sleeve                 | 133/F  |
| Split Collar Assy (complete) | 601/F  |
| Rubber Seal                  | *135/F |
| *Series 1                    |        |

The 595 type connectors are fire-resistant with the split collars made of Ferrobestos material for resistance to external heat. The rubber seal is approved for use in temperatures ranging from -65° to 70°C.

The following procedure should be observed during final installation and tightening.

Ensure that pipes are in alignment. Although the connector has a certain amount of flexibility, an attempt to connect pipes which are out of alignment may distort the rubber seal and result in a leaking joint.

If more than one connector is to be fitted, couple one connector hand-tight to termination or fixed point. Use both-hand-tightness.

Assemble any subsequent connectors in a similar manner, and check for correct alignment of pipe ends at final connector to be fitted. Also check position of line in relation to any brackets or clips fitted. These may have been repositioned at overhaul period.

#### Note

Do not attempt to move pipes more than is necessary for alignment purposes, because flexibility of connector is applicable only after final tightening.

When pipeline has been correctly aligned, tighten connectors progressively with spanner and fitting locking circlip. Correct degree of tightness is achieved by tightening one-quarter to one-half turn maximum from hand-tightness, but circlip must fit tightly around inner sleeve.

#### Note

Take care when tightening connectors. Overtightening will distort rubber seal and may cause leakage. Overtightening may also damage ends, particularly if pipes are manufactured from thin gage material.

Vendor of the coupling is:  
British Aircraft Corporation, Inc.  
399 Jefferson Davis Highway  
Arlington, Virginia 22202

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## BATTERY CURRENT LEAKAGE

### Convair 600/640

A voltage reading between the nickel cadmium battery case and either terminal is not an abnormal condition. This voltage reading may be caused by accumulations of dirt and/or moisture at the post insulator. In addition, deposits of salts resulting from battery gassing, while being charged at a high rate, may provide a path between the battery and case.

Limits have not been established for leaking voltage; however, current flow under these conditions is small and will not adversely affect battery charge.

To minimize current leakage, it is recommended that batteries be cleaned periodically in accordance with instructions in the General Electric Maintenance Manual for batteries.

## NOSE WHEEL SHIMMY

### Convair 340/440

The occurrence of nose wheel shimmy is seldom the result of any one condition, but more commonly is the result of an accumulation of excess clearances which permit gear movement to become easily excited by runway roughness or tire unbalance.

The Convair-Liner co-rotating nose wheel system was designed to dampen shimmy tendencies; however, it cannot be completely effective for all conditions of wear in the NLG strut and steering installation.

Following are some of the factors most generally associated with nose wheel shimmy.

Tires that are unbalanced or out of round.

Tires of uneven diameter, wear, or different tread design.

Excessive looseness in torque arm apex joint, piston attach points, or steering collar attachment.

Excessive backlash between the steering rack and pinion gears in the center steering portion of the gears.

Excessively loose fit of steering collar and bushing to steering collar journal on NLG cylinder.

Excessive looseness between nose landing gear axle splines and wheel drive hub splines, allowing differential wheel movement. This condition could also occur as the result of looseness of the bolts that attach the wheels to the hub.

General loose fit in all movable joints in the landing gear such as trunnion points, drag strut attachment points, etc.

A less common cause for NLG shimmy and vibration reports on Convair 340 aircraft has been a result of worn or loose instrument panel shockmounts which accentuate the apparent severity of both main and nose landing gear vibration.

Production 440 aircraft were manufactured with solid mounts on the instrument panels. Modification of 340 aircraft to the rigid instrument panel configuration has been accomplished by some operators to eliminate panel shockmount problems.

This change is described in the 340/440 Newsletter Review, Page H-35, Item 3.

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## RIVET CHARACTERISTICS

"DD" rivets are made of 2024-T31 aluminum alloy and are refrigerated before driving. These rivets work-harden when aged at normal temperatures. Any subsequent driving will most always cause them to crack. DD rivets that loosen should be removed and new DD rivets installed.

## AIRSPEED LIMITATIONS

### Convair 880/880M/990

One Convair 880 operator questioned the Flight Manual limiting speeds when the inboard spoilers are used for longitudinal control.

This speed restriction is not the result of a performance or flight control limitation, but is imposed as a result of the shift in wing loading. When using split spoilers, there is no speed restriction with the outboard spoilers extended. When using split spoilers with the inboard spoilers extended, there is the speed limitation shown in the Flight Manual. The official explanation is as follows:

1. With all spoilers extended, the center of pressure of the wing is located in almost the same place as when all spoilers are completely retracted.

2. With outboard spoilers extended and inboard spoilers retracted, the center of pressure of the wing moves inboard. This presents no problem.

3. With the inboard spoilers extended and outboard spoilers retracted, the center of pressure of the wing moves outboard. The effect of the outboard center of pressure shift is to increase root bending moment; accordingly, use of the inboard spoilers only, as a longitudinal trim device, is limited to load factors between 0.5g and 2.0g, and airspeeds to 245 KCAS or Mach 0.6, whichever is the lesser, to avoid high wing loading conditions. These limits are shown in the manual.

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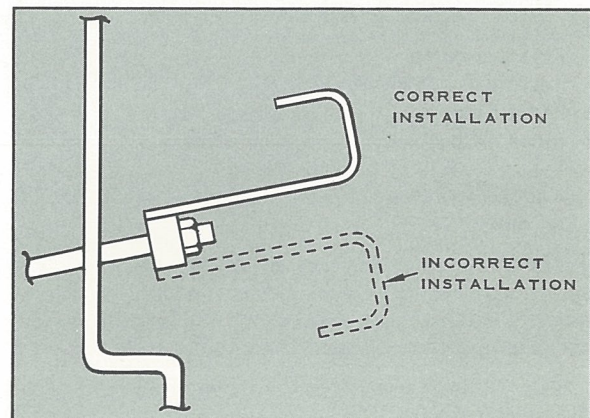
## THROTTLE "T" HANDLE

### Installation

#### Convair 600/640

It has been noted that the throttle "T" handle is installed in two different positions in the field. Incorrect installation could cause pilot confusion at a time when quick action is required.

GD Convair recommends that operators survey their aircraft to see that the handle is correctly installed. The sketch shows the correct and incorrect ways to install the handle.



## LIMITER HOLDER PLACARDS

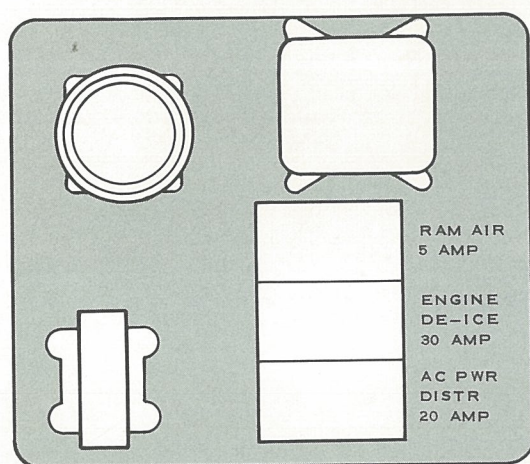
### Convair 600/640

Use of limiters of incorrect ratings can cause incorrect indications and malfunctioning of a unit. In one instance, a 20-amp limiter was installed in place of a 30-amp limiter in the engine deice circuit of a Convair 640. As a result the propeller deice phase OUT light remained illuminated and could not be extinguished.

Conversely, a high-rated limiter or fuse installed in a circuit where a low-rated limiter or fuse is specified could result in wire burning if a fault occurs.

The fuse panels in question are the ones installed in the left- and right-hand nacelles.

As noted on the sketch, fuse ratings are shown on the panel.



FUSE PANEL IN NACELLE

## LOW-PRESSURE FUEL FILTERS

### Convair 600/640

Premature sludging of low-pressure fuel filters can be the direct result of fuel contaminants, often obtained during fueling operations at off bases or under less than optimum fueling conditions. Some cases have been reported where contaminated fuel was obtained directly from the vendors' trucks or storage tanks.

It is advisable to periodically check fuel sources for contaminant levels in order to forestall an impending problem.

Convair would be interested in receiving samples, or being advised of the type of contaminants either found on, or removed from, filter elements, and in the condition of the fuel tank strainers of the airplanes involved.

Rolls-Royce has afforded some relief in this area by specifying a 10-micron low-pressure fuel filter

P/N 77065444 (RR P/N3901616) type MFFA 369-1 in Service Bulletin Da 73-20, Modification 1151. The filter previously specified was a 5-micron P/N 706-4029 (RR P/N 3701511) Type MFFA 280-11. The coarser filter element specified is alternate and interchangeable with the finer element specified. A relatively short service life has been experienced with the finer element because of the fine degree of filtration, and has resulted in some unscheduled removals under certain conditions.

## CALIBRATION of FUEL QUANTITY INDICATING SYSTEM

### Convair 640

In the Convair 240/340/440 Maintenance Manual Supplement for Dart-powered Convairs, the section on Fuel Quantity Indicating System will be revised to correct the decade box setting used for the dry tank procedure for Convair 640's only. The correct figure is 329.7 mmfd instead of 353.0 mmfd.

## OVERHEAT PROTECTION FOR COOLING TURBINE AND COMBUSTION HEATERS PROVIDED

### Convair 600/640

Service Bulletins 2D21-2 and 3D21-1 incorporate an interlock and anti-ice test switch to protect against overheating of the cooling turbine and combustion heater during ground operation.

New components are a fan interlock relay wired in parallel with the fan contactor coil; a ground control relay, operated by the strut switch; and a test switch, springloaded to OFF. All components are standard off-the-shelf parts.

Turbine protection is accomplished by automatically driving open the refrigeration bypass valve during ground operations if the fan contactor coil is not energized.

The right-hand heater is controlled on the ground by interaction of the ground control and interlock relay (cabin heating mode only).

In anti-icing mode, both heaters are deactivated by the ground control relay. The test switch is used for ground checking the anti-ice system. Refer to figures 1, 2, and 3 on pages 14 and 15 for system schematics.

Tie-back of one wire at the hot-air relay is required to interrupt an inadvertent cooling signal which could close the refrigeration bypass valve on the ground with COMB HEAT MAN selected, Fan On, but with the ground cooling valve closed, thus blocking fan flow across the primary heat exchanger.

Operational and checkout procedures are changed as a result of this change. Interim procedures are contained in the affected service bulletins. Formal procedures are to be incorporated in future revisions to Flight and Maintenance Manuals.

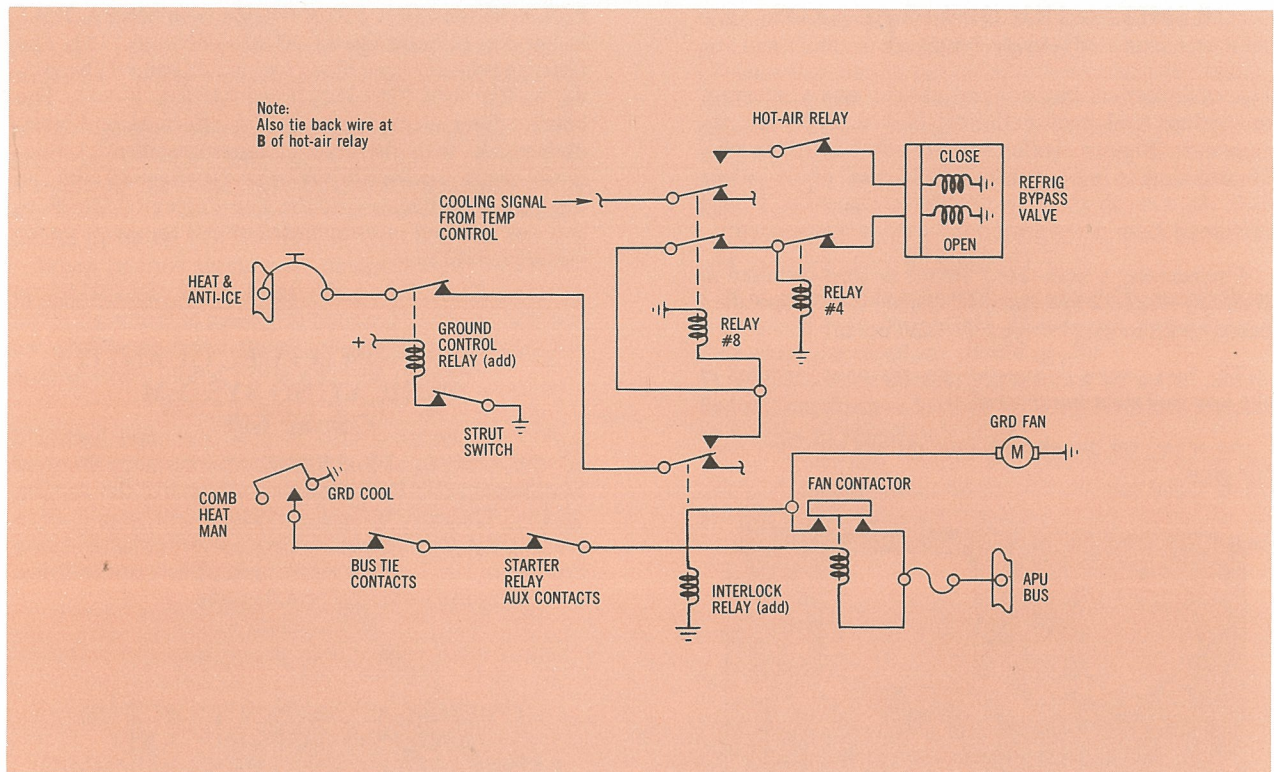


Figure 1. Schematic for 2D only.

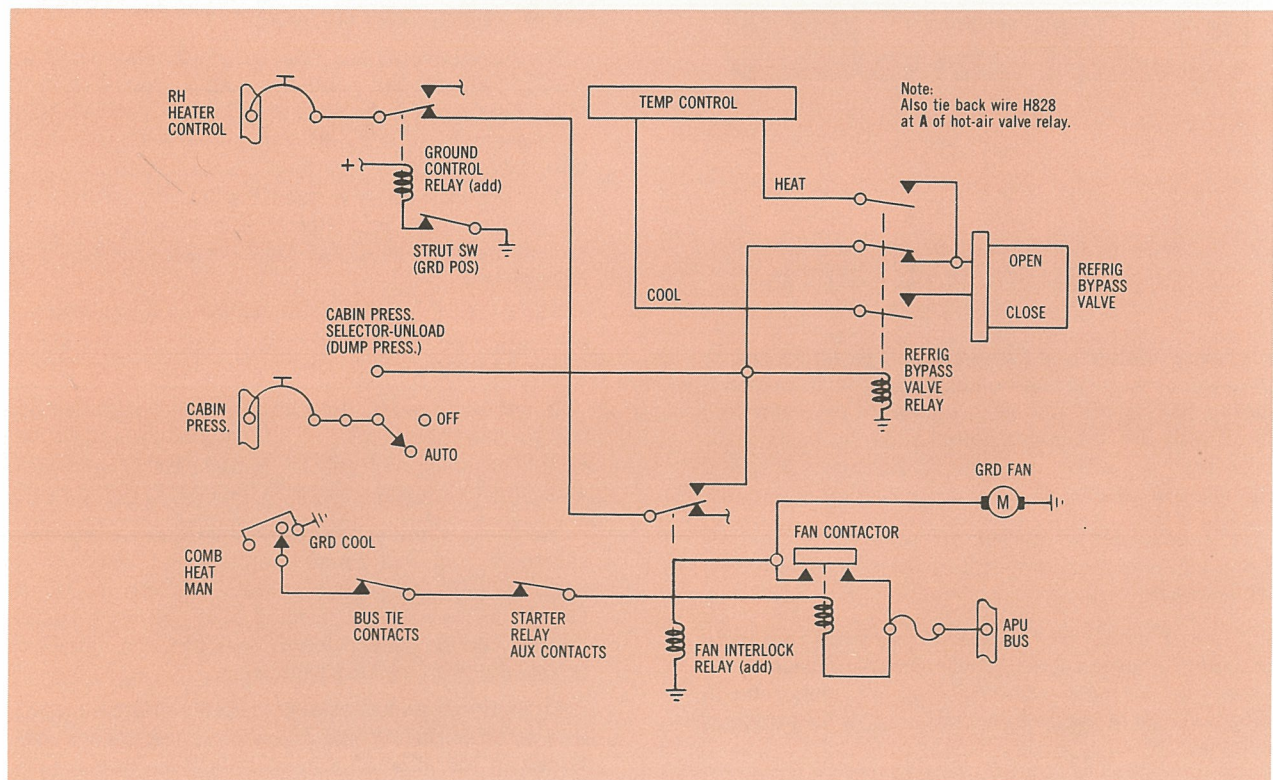


Figure 2. Schematic for 3D only.

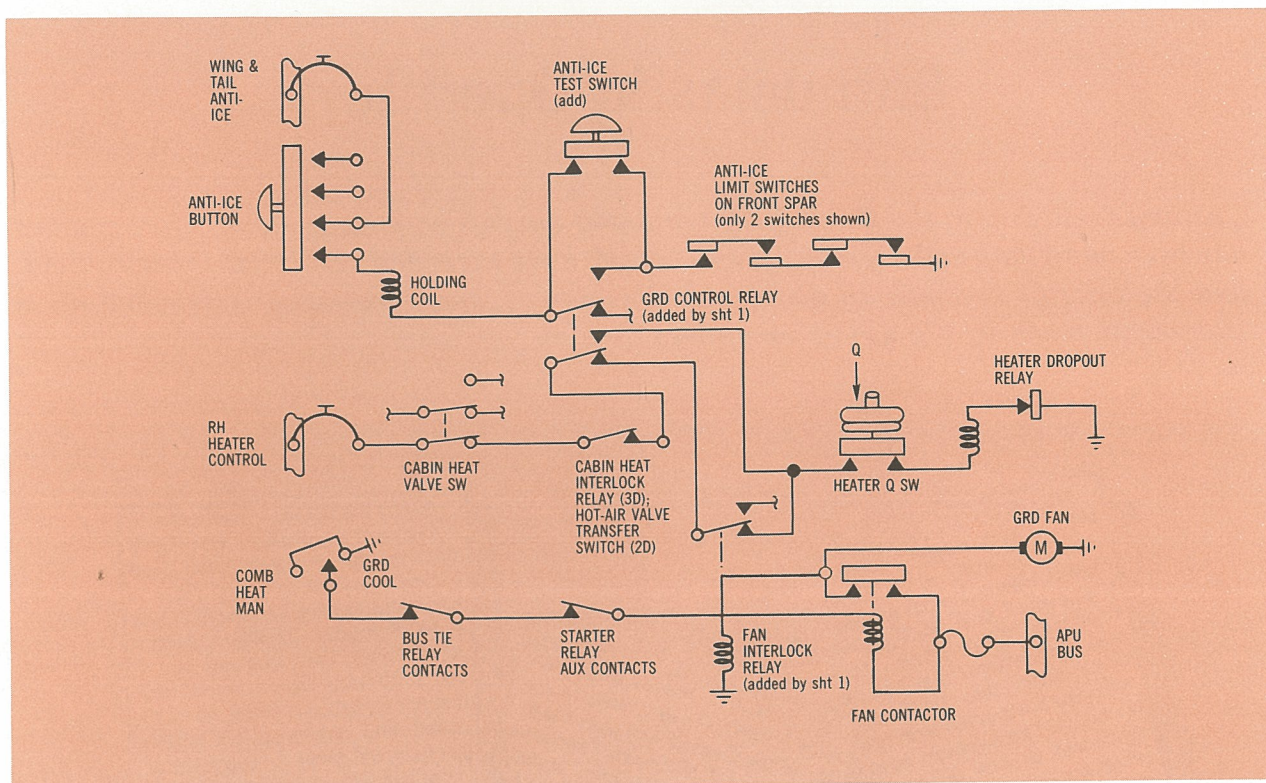


Figure 3. Schematic for 2D and 3D.

# ERRATUM

We goofed in figure 9, page 8, of the September/October issue of the Traveler. We crossed up the third oil line and increase and decrease pitch lines in the left-

hand lower corner. The illustration reproduced below shows the proper sequence. Also corrected is the routing of the engine pressure line from the N.R. valve.

*Sorry about that!*

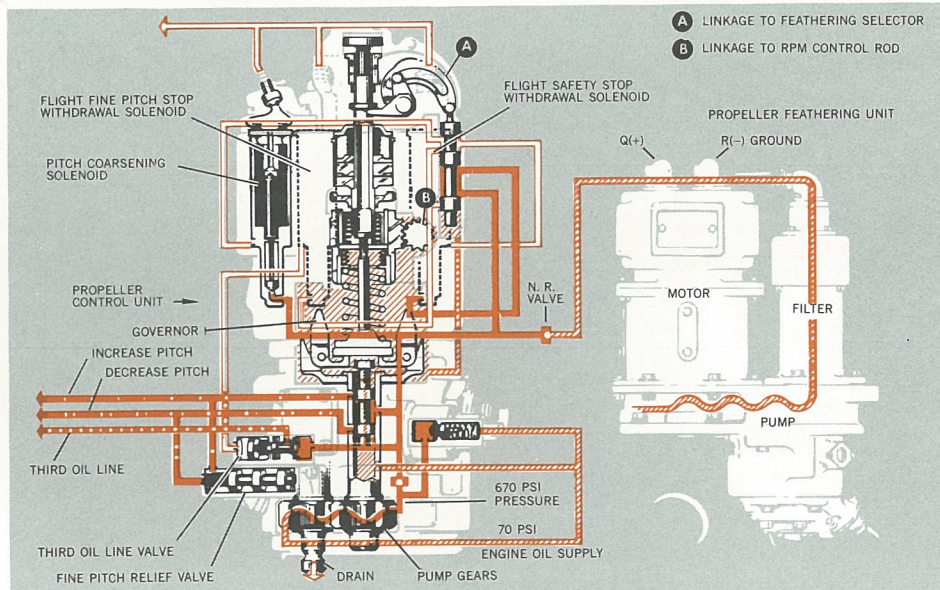


Figure 9. Schematic showing ON-SPEED condition in cruise.

# Enthusiastic Operators

*Customer reaction to the Convair 600 and 640 aircraft with Rolls-Royce Dart engines has been more than enthusiastic. These aircraft have exceeded performance guarantees, and the aircraft continue to distinguish themselves. Just how much is summed up in statements made by top airline executives...*

HOUSTON, Texas, January 12, 1967 - "This airline's decision to convert Convair airplanes to the Dart configuration has proved to be a wise one," R. E. McKaughan, Jr., President, Trans-Texas Airways, said. Performance has been equal to or better than predicted operating costs equal to or less than predicted. The airplanes have been equivalent to new ones as far as passenger acceptance is concerned and the overall reliability of the power plants has virtually eliminated schedule interruptions previously experienced with reciprocating engines. Maintenance costs are much less than original Convairs, McKaughan said.

HONOLULU, Hawaii, January 16, 1967 - John H. Magoon, Jr., President, Hawaiian Airlines, stated, "This airline's experience with the Dart Convair to date has clearly demonstrated the wisdom of its choice, particularly in that it has met or exceeded predicted performance, and operating costs have been equal to or less than predicted. Additionally, passenger acceptance has been excellent and overall reliability for on-time departure and arrival has been outstanding. Maintenance and overhaul costs also have been substantially reduced as predicted," Magoon said.

SAN JUAN, Puerto Rico, February 1, 1967 - In describing operation of the Convair 640 over Caribbean routes, J. M. Sierra, Executive Vice President, Caribair, stated, "We have found the aircraft to be extremely reliable, and all predictions regarding maintenance and overhaul costs have either been met or bettered.

"Maintenance delays have been reduced from 3 delays per 100 departures with an average down time of 1 hour for the 340, to 1.8 per 100 departures with an average down time of 24 minutes for the 640. Considering all new aircraft go through a shakedown period, we feel that the 640 has accumulated an excellent record of reliability," Sierra said.

AMSTERDAM, Netherlands, November 10, 1966 - "The (Dart) airplane has averaged better than 8 hours utilization daily since it went into service last April," said J. M. Schroder, President, Martin Air Charter. Total time has passed the 1500-hour figure. Speed and fuel consumption is better than estimated and passenger acceptance has been excellent... baggage carrying capacity makes the airplane far more versatile than the comparative 40-passenger European turbojet, he asserted.

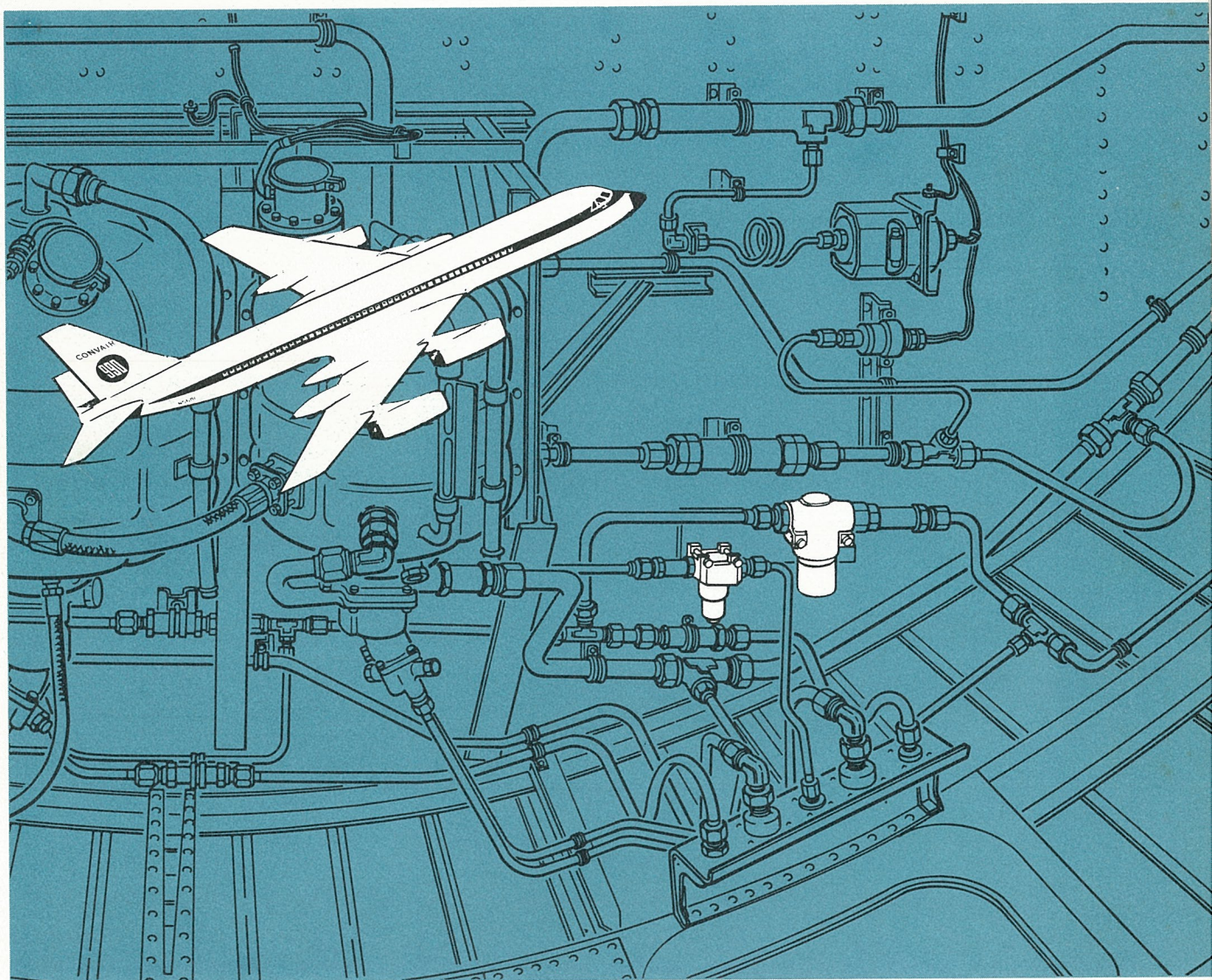
FORT WORTH, Texas, January 12, 1967 - November 1966 completed the first year of Dart operation for Central Airlines. M. Lamar Muse, President, said that, "with a 25 percent larger fleet of Dart 600's as compared to the CV-240's, we are getting 92 percent more production as a result of 18 percent higher daily utilization and 18 percent more miles per hour. "The proof of passenger acceptance," Muse continued, "is that this 92 percent increase in plane miles is producing 122 percent more passenger miles. During the first ten months of 1966, direct plane mile costs of our CV-240 fleet were 96.4 cents; whereas, for the Dart 600, costs have averaged 85.6 cents."

**GENERAL DYNAMICS**  
Convair Division

VOLUME XVIII NUMBER 6 MARCH/APRIL 1967

# Convair *Traveler*

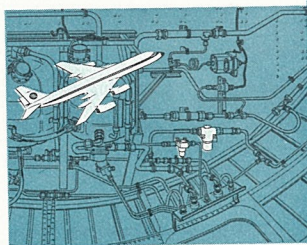
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*In This Issue: Filtering Units - 880/880M/990  
Engineering Clinic*

VOLUME XVIII NUMBER 6 MARCH/APRIL 1967

## Convair *Traveler*



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PACIFIC WESTERN AIRLINES  
Heavy Airlift Specialists

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### OUR COVER

Since the filter plays an important role in keeping our aircraft flying, and since it is the lead article in this issue, Artist Tony Adams felt it was only fitting that it should play an important part on our cover. Although he shows the Convair 990 superimposed over the hydraulic equipment compartment, the article covers all filters in general, but pin-points those on our jet airliner series aircraft.

CONVAIR DIVISION OF GENERAL DYNAMICS

# Filtering Units - 880/880M/990

FILTERING UNITS, although relatively simple units, are vital to aircraft performance. Since fluid and pneumatic systems will not tolerate great amounts of contaminants, filtering elements are provided in critical areas to filter out foreign material, thereby maintaining circulation and free flow of clean fluids to components and subsystems.

Units for filtering out contaminants may be in the form of screens, strainers, or filter elements made from wire cloth, perforated metal, or paper of different ratings.

Filters are rated in microns, or the minimum size of particles they will trap. According to Webster, "A micron is a unit of length equal to one thousandth of a millimeter."

Particles smaller than 5 microns, which cannot be seen with the naked eye, may cause malfunctioning of a system. A buildup of these particles can cause malfunction due to abrasive wear and clogging of small clearances in components. These fine particles can cause a substantial decrease in the life of pumps and other components with close tolerances.

All fluids are subject to contamination; however, all fluids cannot be decontaminated by the same filtering media or techniques. System flow rate usually determines the type of filtration required: overall filter size and weight; system pressure, the pressure imposing strength requirements on the filter case; burst pressure of the filter, which must exceed test pressure, and test pressure which must exceed operating pressure by a safe margin.

To remove minute, barely visible specks, a 40- to 50-micron filter is needed; yet, many aircraft system filters have a 10-micron rating. When you consider that a grain of table salt is 200-microns it is easy to realize that a filter may be clogged with 10-micron particles and not be visible to maintenance personnel. Too, as particles build up, filtration becomes progressively finer until the filter becomes completely clogged.

In general, filters are rated to remove 98% of the particles of the dimension specified. Since most particles are not perfect spheres, 100% filtration cannot be achieved.

Hydraulic systems in Convair aircraft generally use two types of filters: stainless steel wire mesh and paper (Micronite) filters of resin-impregnated cellulose. The wire mesh type is used in the high-pressure system (3000 psi); whereas, the paper type is used in the case drain or low-pressure side of the hydraulic system.

Paper elements are disposed of when they become contaminated; therefore, a periodic inspection at prescribed intervals is mandatory to keep hydraulic systems from being compromised.

Most filters have replaceable elements that are easily removed for cleaning or replacement. Cleaning of some types of elements requires special equipment which is not usually available at the line maintenance

level. The design of the filter is such that the element may be removed for servicing and inspection without disconnecting the line fittings or disturbing the filter mountings; however, in hydraulic systems, pressure must be reduced to zero when replacing the filter, but the system need not be drained.

Some filters have a red pop-up indicator button on top of the filter. When pressure drop across the element exceeds a specified amount, the indicator button extends approximately 1/8 inch and remains extended until it is manually depressed. This button informs maintenance personnel of excessive drop in pressure across the filter element, indicating the element needs servicing. The indicator will not operate if temperature of hydraulic fluid is below 32°F (0°C).

Some filters have an automatic shutoff which permits servicing the filter while maintaining system pressure. Only a minimum amount of air may be introduced into the filter housing during servicing and this air can be bled off through the bleed plug incorporated in the assembly.

Any time metal is found in a screen or filter, the fluid should be strained to prevent loss of any other metal. This metal should then be analyzed and identified so as to troubleshoot and locate the source of failure of a unit within the system.

The following procedure is used by a Convair 880 operator.

- Isolate steel particles by using a permanent magnet. Use a Kleenex tissue over the magnet to assist in removing steel from the magnet.

- The particles can be distinguished by their low melting point. This can be accomplished with a clean soldering iron heated to approximately 260°C (500°F) and tinned with 50-50 solder (50% lead, 50% tin). *Wipe off excess solder.* A tin particle dropped on the heated iron will melt and fuse with the solder. *Avoid excessive overheating of the iron during this test.*

- Aluminum particles may be determined by their reaction with hydrochloric acid. When a particle of aluminum is dropped into hydrochloric acid, it will fizz with a rapid emission of bubbles, gradually disintegrating to form a black residue. Silver and copper (or bronze) do not react noticeably in hydrochloric acid.

- Silver, copper, or bronze may be distinguished by their respective reaction to nitric acid. A silver particle will react rather slowly when dropped into nitric acid, producing a whitish fog in the acid; whereas, a particle of copper or bronze dropped into nitric acid will react rather rapidly, producing a bright green cloud in the acid.

When "panning" an oil screen, use a small container approximately 10x5x4 inches. First separate screen disc and wash with Varsol. Then place a Kleenex tissue over the 200-mesh strainer and pour the Varsol and residue into the Kleenex; wash the pan with a small amount of chlorothene and pour over screen

residue. To assist in faster drying of the residue, place the tissue on a Scott paper towel which will absorb some of the moisture from the residue. Metal particles are more readily detected when the screen residue has dried out.

**Note**

Be sure the wash pan is clean before washing screen in it.

When an engine is removed prematurely, all metal particles and screen residue should be placed in a plastic bottle and attached to the engine. A screen check sheet should be completely filled out and attached to the engine also. On piston engines, the check sheet and bottle are attached to the CO<sub>2</sub> line; on jet engines, to the fuel control linkage.

A new filter that appears to be clean may still contribute a small amount of contamination. To reduce this possibility, some filter manufacturers now pre-clean their new filters; then seal them in packages before delivering them to the customer. Filters should remain in the sealed packages until they are ready for installation.

Normally, there is a predetermined pressure drop across a cleaned filter—even a new one. As the filter strains contaminants from the fluid, it begins to clog, and the pressure drop, after a period of time, increases. After the filter reaches its dirt-holding capacity, it may bypass. (Pump discharge filters on Convair jet airliners do not incorporate a bypass.) It is then necessary to clean or install a new filter element.

It has been found through tests that particles less than 5 microns in size continuously circulate in the fluid, acting as a "lapping" compound. These particles get between moving parts, grinding away on the surfaces of the pumps, causing wear and reducing pump life.

Recent tests with a 3-micron filter, developed by Aircraft Porous Media and installed in jet aircraft, have shown that in normal operation, aircraft have contamination levels averaging 40,000 to 50,000 particles greater than 5 microns per 100ml. The silting index (a measure of particles less than 5 microns) ranged from 2.25 to infinity.

With the 3-micron filter, pump failures were substantially reduced, and the need for system flushing was eliminated. Increased service life of the system components resulted in a substantial saving to the airlines.

This absolute 3-micron filter (Ultipor. 9 Triphane) is available from Aircraft Porous Media for installation in the return lines of each hydraulic system, directly upstream of the system reservoirs. All fluids which return to the reservoirs would then be filtered through the 3-micron filter.

The Ultipor. 9 Triphane filter assembly (figure 1) consists of a primary stage disposable element, which furnishes absolute 3-micron filtration; a second-stage all stainless steel filter element of Supramesh with an 18-micron absolute rating. The second-stage element protects the system in the event the primary stage should fail as a result of excessive differential pressure. It also protects the system from contamination while

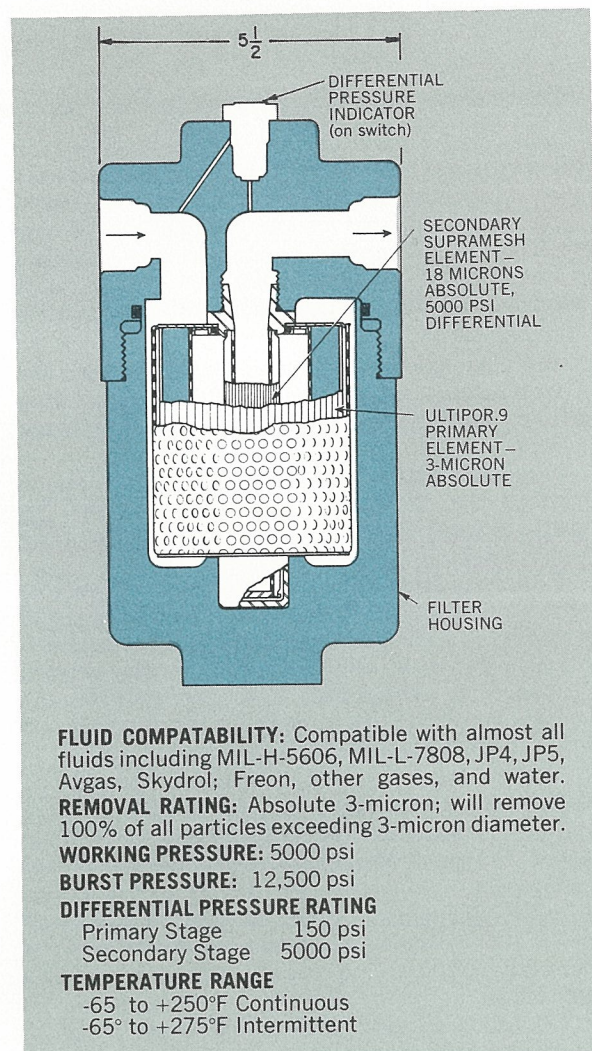


Figure 1. Ultipor®9 Triphane® 3-micron filter.

the primary-stage element is being replaced. Under normal operating conditions, the secondary stage element remains clean indefinitely.

A differential pressure indicator (red button) set at 100 psi  $\pm$  15% provides visual indication when the primary stage element requires replacement.

Figure 2 is typical of the performance of a filter with a rated capacity of 40 psi. Note that the pressure drop remains fairly uniform at about 5 psi until a considerable amount of filtering is accomplished; then, the pressure drop increases rapidly as the filter becomes contaminant-saturated.

To assist the operator, Aeronautical Recommended Practice (ARP) #725 contains criteria for determining the effectiveness of any type of filter cleaning procedure. This document may be obtained from Aircraft Porous Media, Glen Cove, New York.

Contamination of the downstream side of the filter may be determined by information contained in ARP 599, also available from Aircraft Porous Media. This check determines the effectiveness of a filter before and after ultrasonic cleaning procedures.

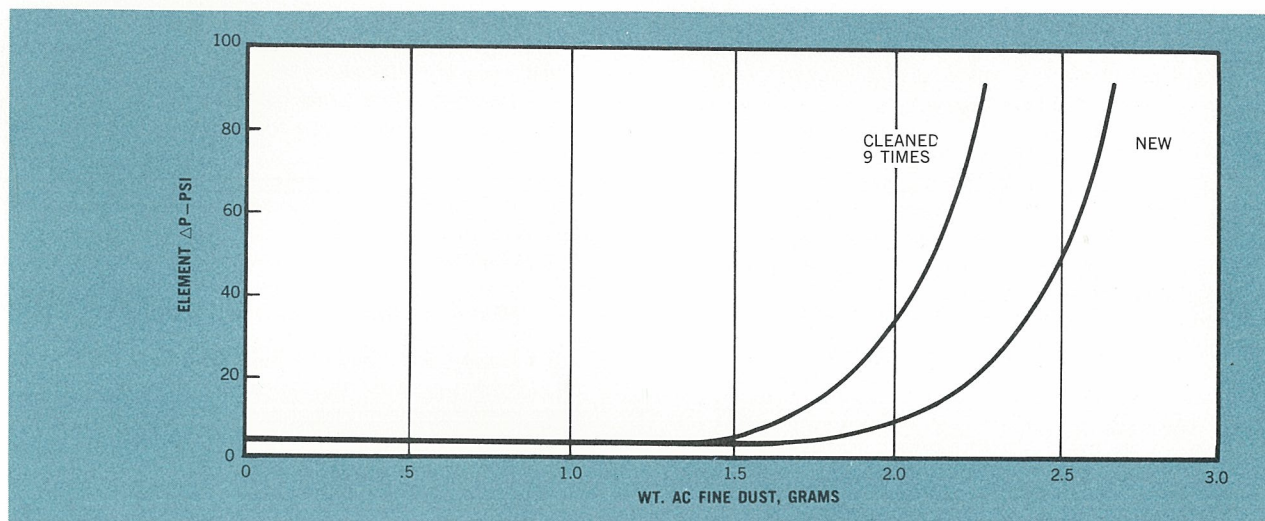


Figure 2. Filter element dirt-holding capacity.

Because of the close tolerances between working surfaces of components in aircraft hydraulic systems, even small quantities of very fine contaminants could cause binding, scoring, and wear between these working surfaces; therefore, the filters must be carefully maintained so that they do a thorough cleaning job.

Formerly, the prescribed method for cleaning filters was to "swish and swash" the filter element in a solvent until it looked clean. Now, with more rigid filtering requirements, a finer filtering action is required—filtering particles in sizes 10 to 25 microns (.00039-.00098). Cleaning such fine filters has produced a problem, and various methods have been tried and carefully checked.

At present, the ultrasonic method along with a solvent bath, as called out in the Manufacturer's Overhaul Manual, is quite effective. As an example, in tests with new unused filters, simple rinsing removed a particle count of 5000 from a 10-25 micron size filter; ultrasonic cleaning removed a particle count of 210,000 from a new unused filter.

To show that the ultrasonic method was accomplishing what rinsing could not, filters were cleaned with repeated rinsings until the particle count stabilized. Then, the filters were subjected to the ultrasonic method, and considerably more loose material was extracted. This involved passing 2000 cc of solvent through the filter during ten minutes of ultrasonic vibration at 26 kilocycles from a 400-watt generator, in accordance with ARP 599.

All washing processes, including ultrasonic cleaning, employ a liquid medium which alters the chemical or physical properties of the contaminant to be released. The contaminant is either dissolved or is held in suspension by this medium, or a secondary contaminant, bonding the primary contaminant particles, is removed, allowing the particles to fall free from the object immersed in this liquid.

In ultrasonic cleaning, the liquid medium in the cleaning chamber is totally permeated by an intensive scrubbing action, termed cavitation, which accelerates the performance of the liquid medium and pro-

duces uniform cleanliness of all surfaces of the part wetted by this medium.

In ultrasonic cleaning, as in most liquid cleaning processes, a rinse is recommended following cleaning. This rinse eliminates dissolved contaminants, which are redeposited on the part when it is withdrawn from the cleaning solution.

The most practical method of cleaning filter elements appears to be a combination of rinsing by back-flushing and ultrasonic vibration, and repeating the cycle five or six times.

In this way, a practical maximum amount of loose material is removed from the filter elements. In most cases, 85% (or better) of the original new filter capacity is restored.

Following is a typical manufacturer's procedure for cleaning wire mesh elements.

Immerse contaminated element in petroleum ether and blow compressed air through from the inlet direction. Continue for several minutes. This step removes readily removable contamination particles.

Install element in suitable housing on a hydraulic test stand, and flow hydraulic fluid in the reverse direction for an hour or longer. Maintain as high a flow rate as possible, so long as pressure drop is not excessive. Exercise care so that convolutions do not distort or burst.

Perform the following cleaning cycle under ultrasonic conditions with fluid temperatures at 150° to 160°F, and with sump fluid continuously filtered.

1. With element port facing downward, clean element for five minutes with detergent and water.
2. Flow detergent and water (with maximum flow) through inside of element for two hours. Inspect element convolutions under microscope. If wire mesh pores appear plugged, continue cycle until pores appear clean.
3. Apply suction to draw detergent and water through element in normal flow direction for one hour.
4. Test element for absolute micron rating by bubble point method in Solox 190, filtered to two-micron level.

5. Repeat step 3 with perchloroethylene for 20 minutes.

6. Rinse inside and outside of element with petroleum ether, filtered to two-micron level.

7. Oven dry at 105°C for minimum of 15 minutes. Cool in desiccator to room temperature.

8. Heat-seal in a clean, dry polyethylene bag.

The pressure drop ( $\Delta P$ ) across the element should be accurately measured. A pressure drop greater than specified for a particular element indicates that re-cleaning or rejection is required.

In addition to the need for assurance that the element has been adequately cleaned, and that it removes particles with the desired efficiency before re-use, it is necessary to measure the "bubble point" of the element. The "bubble point" test per WADC TR 65-249 enables the filter user to determine the largest opening in a filter element.

The Pall-Cavitron "Hips Element" cleaner combines the  $\Delta P$  and bubble point tests in a single mobile unit.

A new filter will remove more weight in fine "dust" than will a thoroughly cleaned used filter. A clean used filter is slightly more efficient in particle removal, however, because the larger filter pores have become clogged with particles that are wedged in place. Thereafter, only the finer pores are open, and the filtering action becomes more efficient. A filter rated for 10 microns (.00039) has approximately 225,000 openings per square inch.

During no-flow periods (when the hydraulic system is shut down), the filtering capacity of the filter elements is partially restored. Particles that were held in place by fluid pressure now drop away from the filter surface and into the bottom of the filter where they remain.

Instructions in the Maintenance Manual should be carefully followed when removing, cleaning, and installing filters. Before removing a filter or filter element, the entire unit should be wiped clean with a lint-free cloth or paper to prevent contamination. Fluid lines should be capped immediately and the filter element placed in a polyethylene bag to protect it against physical damage and further contamination.

When its contents are ready for use, the polyethylene bag should be cut, not torn, open to preclude the introduction of small bits of the bag into the hydraulic system.

The following information may be used in addition to information contained in the Maintenance Manuals when replacing filter elements.

- Remove filter bowl and filter element. Place each in a polyethylene bag for future processing.

#### Note

A filter element may appear clean to the unaided eye but still may be partially or even completely clogged. *Do not reinstall a used filter element because it "looks" clean. Always install a cleaned or new element.*

- Empty filter bowl of fluid and flush with clean oil. Check to ensure that no heavy contaminants remain in bottom of filter bowl.

#### Note

Wear particles in the filter bowl may be the first indication of impending pump or component breakdown.

- Install a new O-ring, Vee ring, or other seal as required on clean filter element in head or filter housing. If filter element contains a snap ring, it will be necessary to place filter element in filter bowl filled with a clean system fluid before installation in head of filter housing. The snap ring should engage the groove inside the filter bowl.

- If filter assembly incorporates a differential pressure indicator, be sure to reset the indicator by pressing red indicator button firmly with finger.

Replacement intervals of filter elements are best determined empirically, because factors affecting filter element life vary considerably.

To provide improved service reliability and performance, the following service routine is recommended.

Replace filter or clean element —

- Whenever a differential pressure indicator indicates a dirty filter:
- After system fluid change:
- After any repair or maintenance of the hydraulic system;
- Element change after 250-350 hours of service. This may coincide with an operator's scheduled maintenance of other aircraft components.

Following is a list of typical filter units, their functions, part numbers, and Convair aircraft applicability.

#### HYDRAULIC SYSTEM

| Aircraft    | Spec Control Number | Vendor and Number                         | Element Number          | O-Ring Number       | System                           | Remarks   |
|-------------|---------------------|---|-------------------------|---------------------|----------------------------------|---|
| 880<br>880M | 22-08429-1          | Aircraft Porous Media filter<br>AC-137346 | AC-1373E-16             | AA1373-214<br>2-214 | Low-Pressure<br>Pump Supply Line | 17-micron low-pressure filter accessible thru filter access door, LH side of each pylon. Red indicator pops up when pressure exceeds 3.5 psi. Relief valve allows fluid to bypass filter if element becomes clogged (figure 3). |
| 990         | 30-08454            | Bendix<br>1726910                         | Micronite filter 039024 | 039043<br>040639    |                                  | Disposable Micropleat element. Removes 100% of foreign particles over 20 microns and 98% over 7.5 microns. Accessible thru filter access door LH side of each pylon (figure 4).   |

# HYDRAULIC SYSTEM

| Aircraft           | Spec Control Number      | Vendor and Number   | Element Number           | O-Ring Number                               | System                                     | Remarks   |
|--------------------|--------------------------|---|--------------------------|---|--|---|
| 880<br>880M        | 22-08428-1               | Aircraft Porous Media filter<br>AC-1574-12                      | AC-1574E-12              | AA1574-12D130                               | Pump Pressure Line                         | 10-micron high-pressure filter accessible thru filter access door, LH side of each pylon. Red indicator pops up when pressure drop across element exceeds $100 \pm 15$ psi (figure 3).                    |
| 990                | 30-08453-1               | Aircraft Porous Media filter<br>AC2990-12                       | Wire mesh<br>AA2990-214  | AA2990-138<br>AA2990-214                    |  | Rigimesh element of corrugated stainless steel.   |
| 880<br>880M        | 22-08464                 | Bendix<br>1726954   | A1726969<br>Micronite    | A573802<br>A513814                          | Pump Case Drain Line                       | Accessible through filter access door in pylon. Pop-pet relief valve bypasses filter if it becomes clogged. Disposable element (figures 3 and 4).   |
| 880<br>880M<br>990 | 22-08434-1<br>22-08428-3 | Purolator Prod. Filter 60878<br>Aircraft Porous Media AC1574-12 | 64099<br>AC1574E-12      | 57694-11<br>AA1574-12D-130<br>AA1571-12D018 | Auxiliary Hydraulic System                 | 10-micron filter in fwd LH corner of hydraulic compt. Red indicator pops up when pressure drop across filter exceeds $80 \pm 10$ psi. Element of convoluted stainless steel wire cloth (figures 5 and 6). |
| 880<br>880M<br>990 | 22-08461-1               | Purolator Prod. 62289   | 65354 st st wire & cloth | 57694-22<br>57694-9                         | Reservoir Remote Pressure Fill Port        | 50-micron filter located in LH corner of hydraulic compt, fwd of door. Replaceable element of convoluted st st wire cloth (figures 5 and 6).  |
| 880<br>880M<br>990 | 22-08437                 | Airite Prod. 63-11002   | Screen                   | Convair P/N 96-58523-045                    | No. 1 System Reservoir Manual Filler Port  | 80-mesh screen in fill port at top of reservoir (figure 7).   |
| 880<br>880M<br>990 | 22-08438                 | Airite Prod. 63-11006   | Hat-Shaped Screen        | 63-11027                                    | Nos. 1 and 2 Reservoirs, Pump Suction Line | 50-mesh screen in bottom of each reservoir, to filter fluid as it enters hydraulic boost pump (figure 7).   |

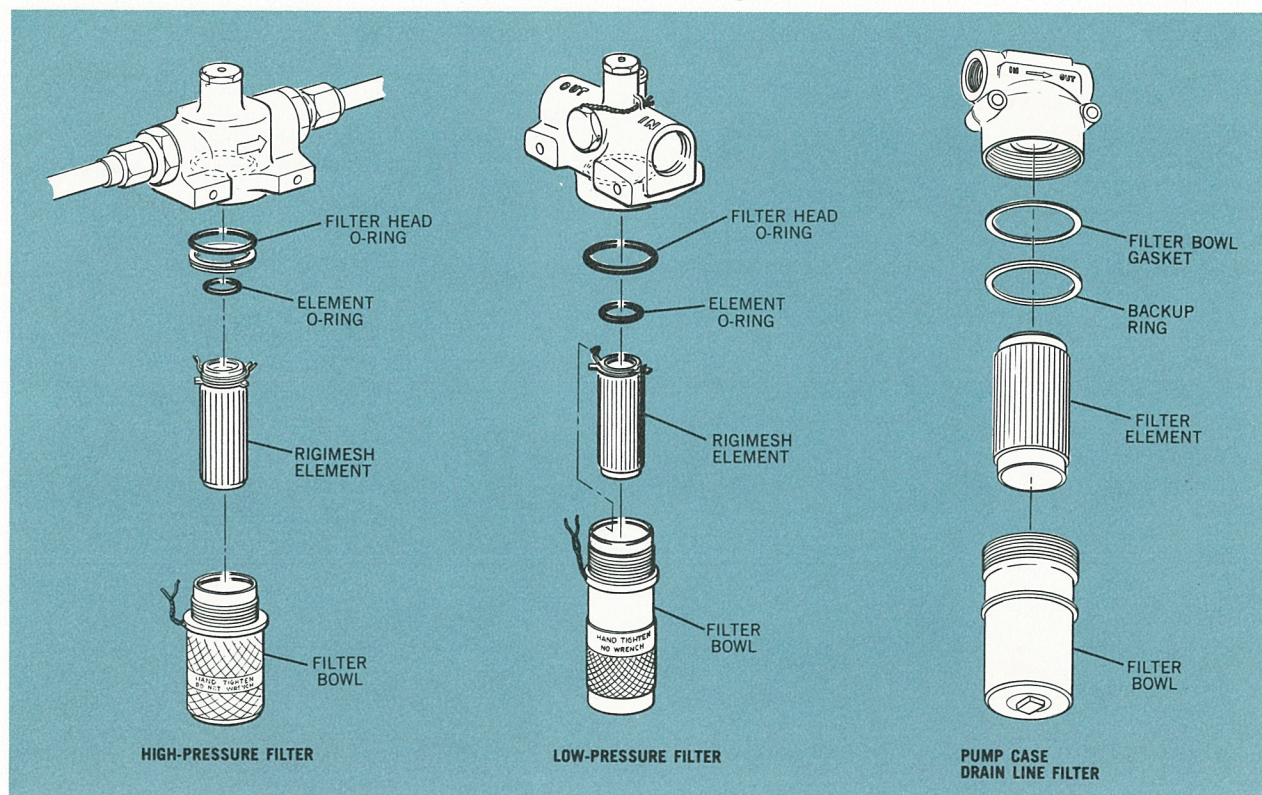


Figure 3. Filters accessible through filter access door in pylon (880/880M)

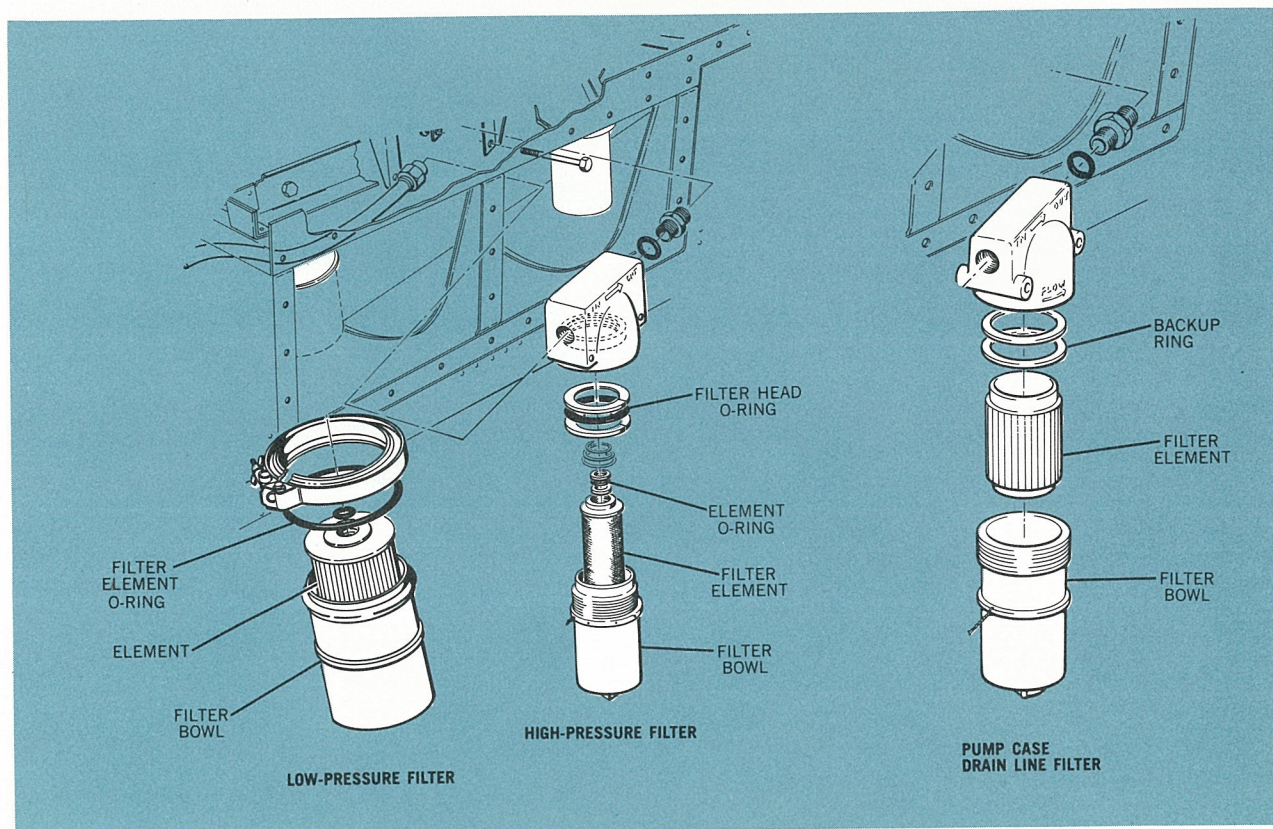


Figure 4. Filters accessible through filter access door in pylon (990)

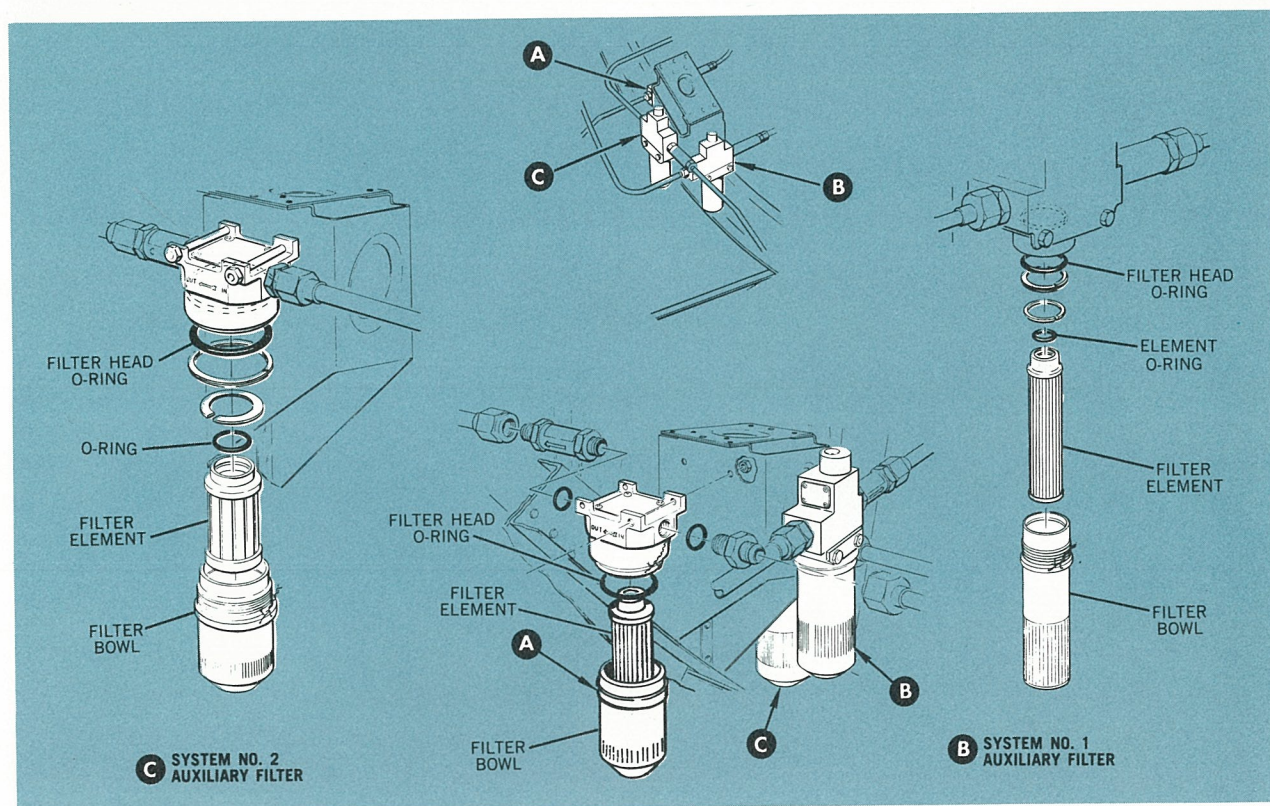


Figure 5. Convair 880/880M filters accessible through hydraulic compartment door (typical).

# FUEL SYSTEM

| Aircraft           | Spec Control Number | Vendor and Number                     | Element Number                          | O-Ring Number              | System   | Remarks  |
|--------------------|---------------------|---------------------------------------|---|----------------------------|--|--|
| 880<br>880M<br>990 | 22-02657-1          | Accessory Prod.<br>904900             | Line-Mounted<br>Fuel Strainer           | ---                        | Control Line<br>Strainer Instal.                       | In line between refuel shutoff valve and refuel pilot valve. CRES steel wire, type 302; 0.028 gage, accessible thru access doors in wing lower surface; checked and cleaned only at overhaul (figure 8). |
| 880<br>880M<br>990 | 22-02557-3          | WEMAC Co. &<br>Airite Prod.<br>2557-3 | Screen                                  | ---                        | Fuel Transfer<br>and Jettison<br>Bellmouths            | 8-mesh screen of CRES steel wire, type 302; 0.028 gage; accessible thru access doors in wing lower surface; checked and cleaned only at tank overhaul (figures 9 and 10).                                |
| 880<br>880M<br>990 | 22-02657-1          | Accessory Prod.<br>904900             | Screen                                  | ---                        | Refuel/Defuel<br>System in Refuel<br>Pilot Valve Lines | 64 x 56 mesh screen in replenishment tanks.  |
| 880<br>880M<br>990 |                     | General Electric<br>308D668P2         | Aircraft<br>Porous Media<br>AC1512E-161 | MS29513-121<br>MS29513-233 | Between Fuel<br>Heater and Fuel<br>Control             | 46-micron sinter-bonded steel wire cloth screen. If filter becomes clogged, fuel is bypassed.  |
| 880<br>880M<br>990 |                     | Bendix                                | 388314<br>Screen                        | 388246<br>388040           | Fuel Nozzle Assy                                       | 100-120 mesh screen (figure 12).   |
| 880<br>880M        | 22-02557-1          | WEMAC Co. &<br>Airite Prod.<br>2557-1 | Screen                                  | ---                        | Fuel Jettison<br>Standpipe                             | CRES steel 8 x 8 square mesh cloth.  |
| 990                | 22-02657-1          | Accessory Prod.<br>904400             | Screen                                  | ---                        | Refuel/Defuel<br>Line                                  | Outbd of LH and RH anti-shock bodies; 64 x 56 mesh screen  |
| 880M<br>990        |                     | Accessory Prod.<br>904900             | Screen                                  |                            | Refuel/Defuel<br>Line                                  | Center section fuel tank; 64 x 56 mesh screen.   |

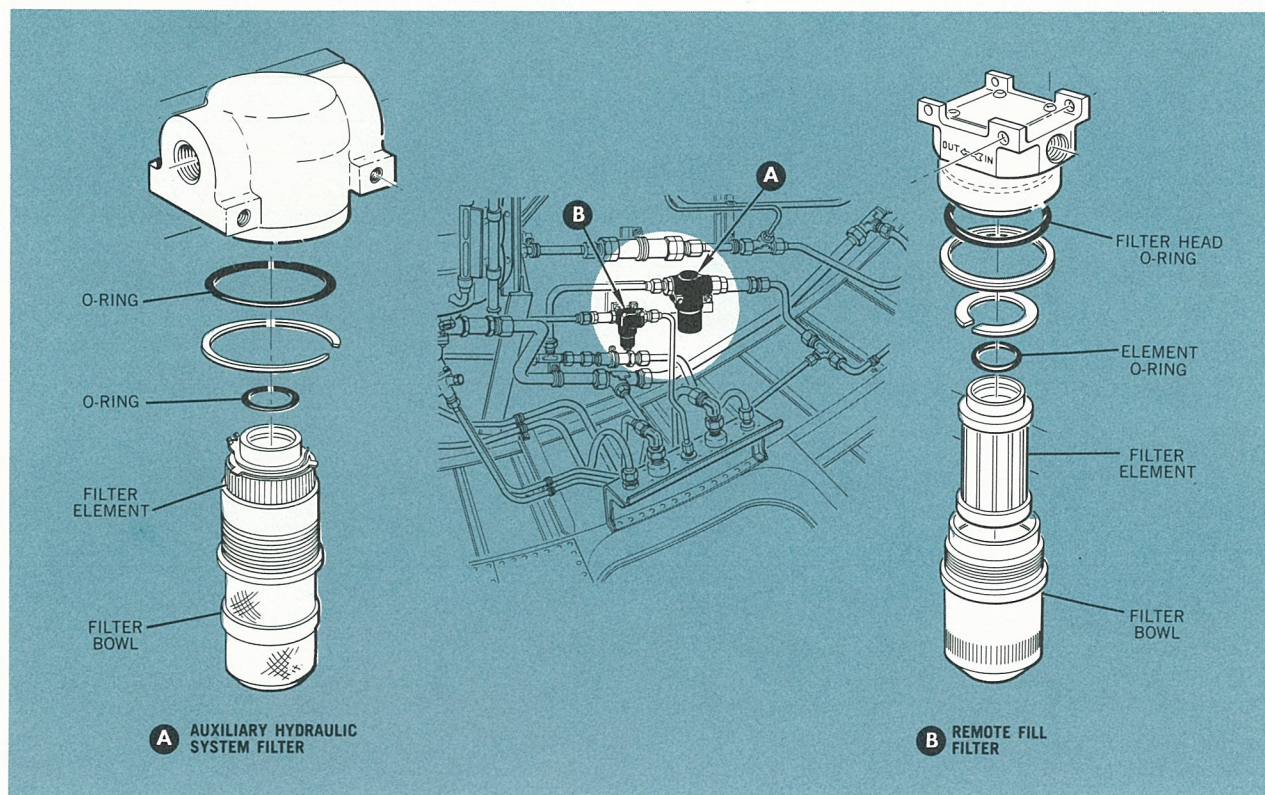


Figure 6. Convair 990 filters accessible through hydraulic compartment door (typical)

# MISCELLANEOUS

| Aircraft           | Spec Control Number      | Vendor and Number               | Element Number                        | O-Ring Number            | System                             | Remarks   |
|--------------------|--------------------------|---------------------------------|---------------------------------------|--------------------------|------------------------------------|---|
| 880<br>880M<br>990 | 22-28141-1<br>22-28142-3 | Ludlow-Saylor Corp 301967       | Screen                                | — — —                    | Cabin Pressure Regulator           | Stainless steel 0.035 screen, 4-mesh.   |
| 880<br>880M<br>990 | 22-02470-5               | AiResearch PS135157-4           | Filter Screen                         | — — —                    | Cabin Pressure Ground Test Fitting | Air conditioning low-pressure pneumatic system.   |
| 880<br>880M<br>990 | 93-789-00-002            | Everpure S1B                    | 150 G                                 | 344                      | Water Purifier Unit in Each Buffet | Element of bronze and plastic; to filter out odor, taste, and foreign matter.                           |
|                    |                          | Ogden Filter Co. AC2            | 150B                                  |                          |                                    |   |
| 880<br>880M<br>990 | 22-02414                 | 92002-11 Cleveland Pneu.        | Filter                                | Internal Retainer Ring   | Steering Control Valve             | 0.008 particle size filter installed within valve.  |
| 990                | General Elec. 874C146P2  | Aircraft Porous Media AC3394-81 | AC3394E8                              | AA3394-132<br>AA3394-014 | Thrust Reverser                    | Installed at 7:30 position near center of rear compressor stator, to filter oil from pump to reversers. |
| 880<br>880M<br>990 |                          | General Electric 105B2789       | Shaw Aero Device Inc 417-130 Strainer | MS29561                  | Oil Tank Cap and Dipstick Assy     | Alternate vendor, Wisco Products, Dayton, Ohio.   |

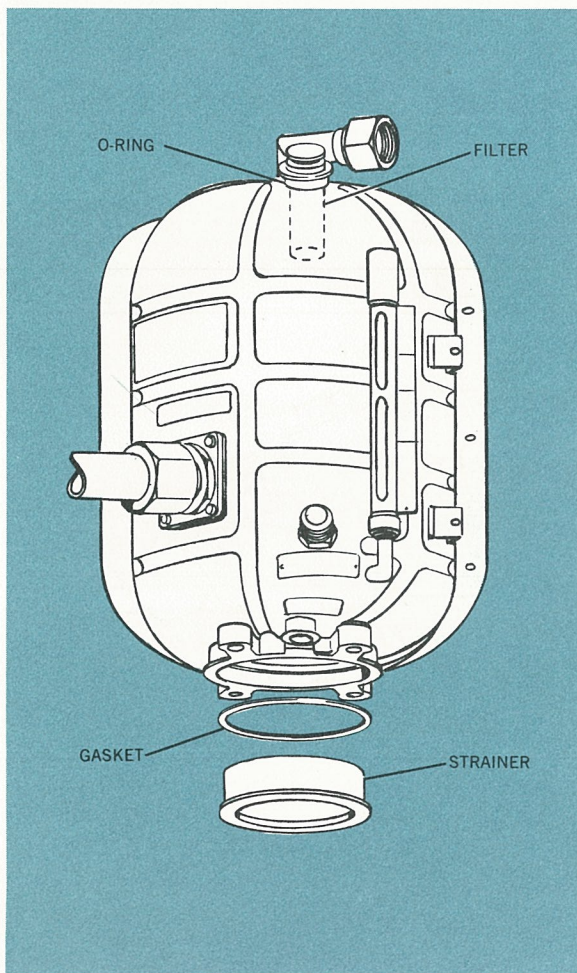


Figure 7. Hydraulic reservoir showing typical filter and strainer installation.

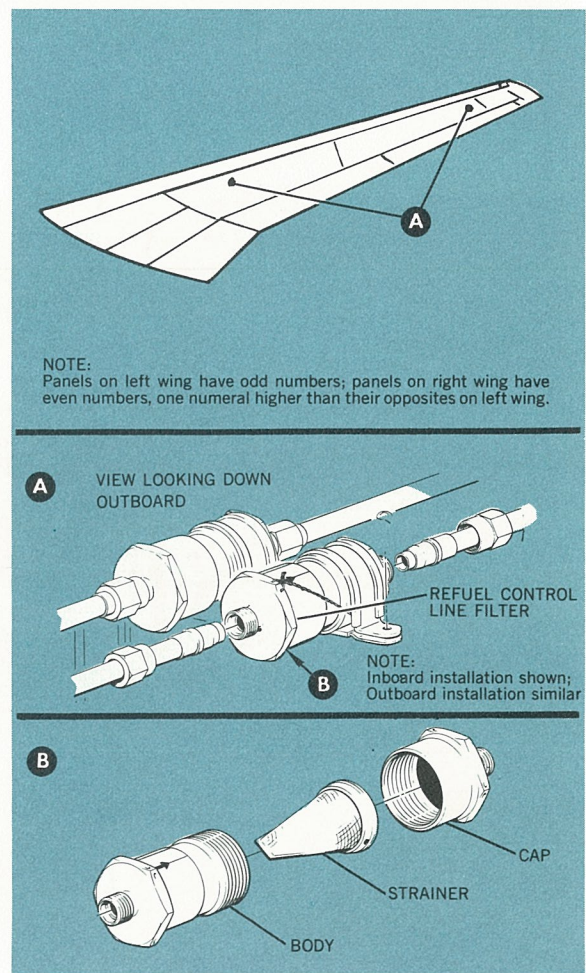


Figure 8. Typical control line strainer installation in wing (880/880M/990).

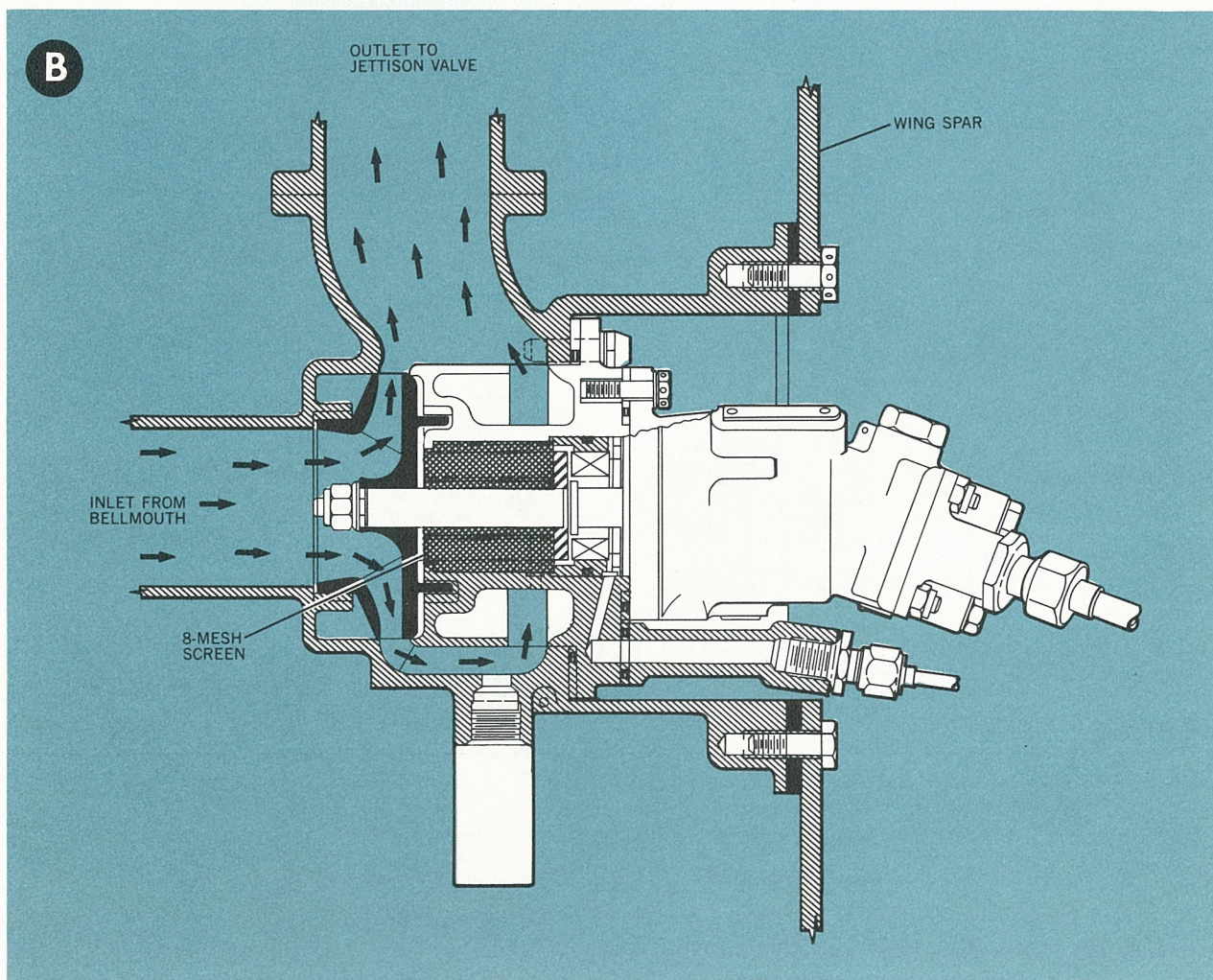
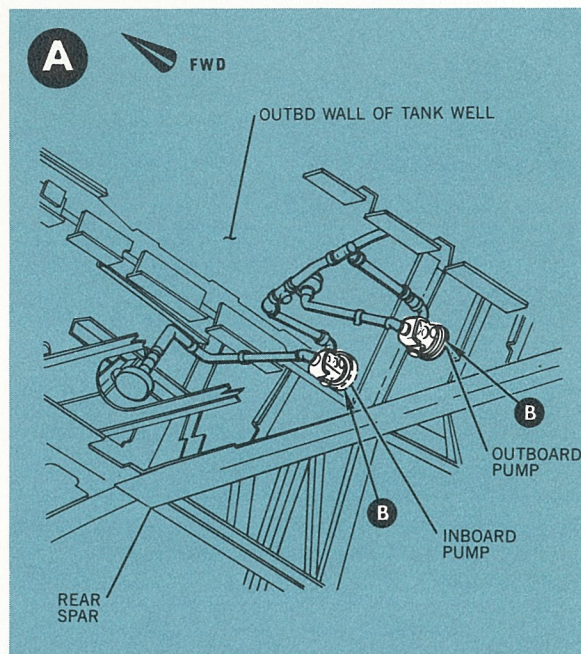
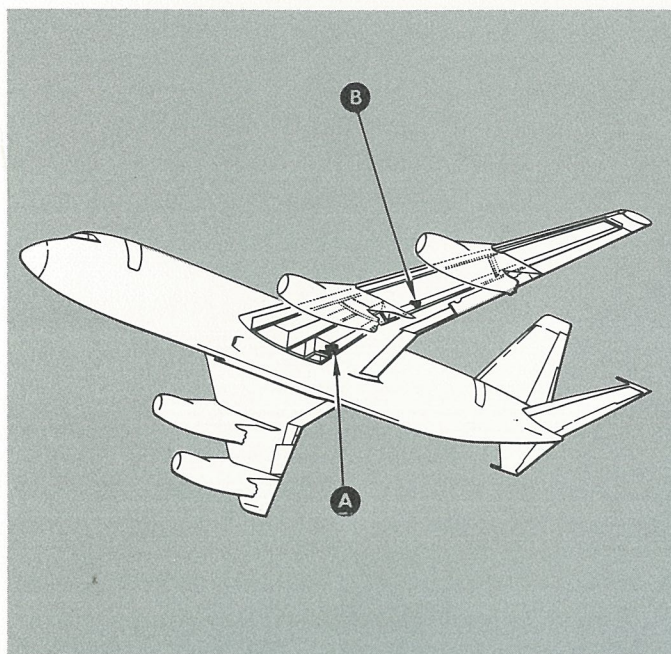


Figure 9. Typical fuel jettison pump schematic showing screened inlet from bellmouth.

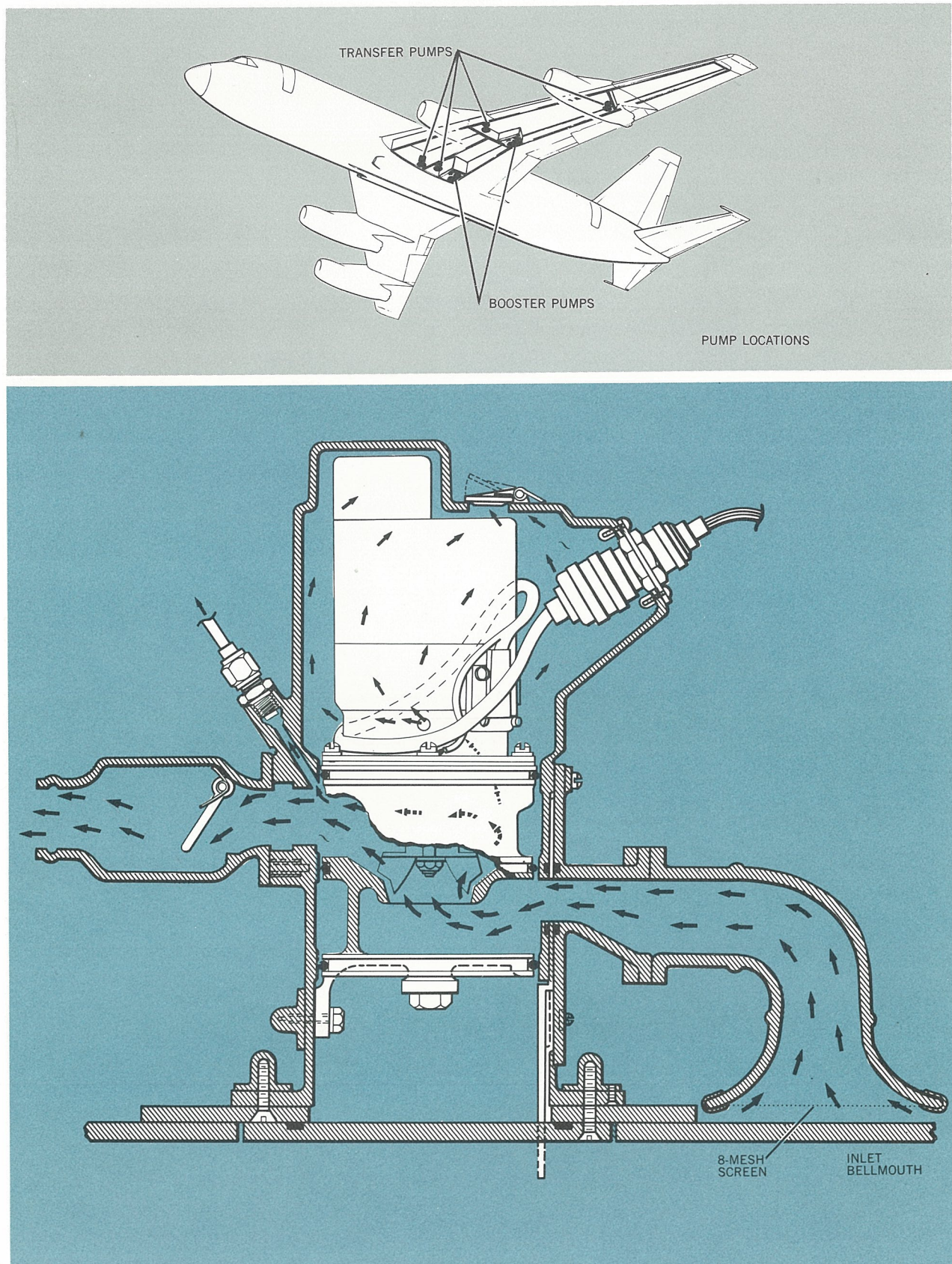


Figure 10. Typical transfer and fuel pump schematic showing screen at inlet bellmouth.

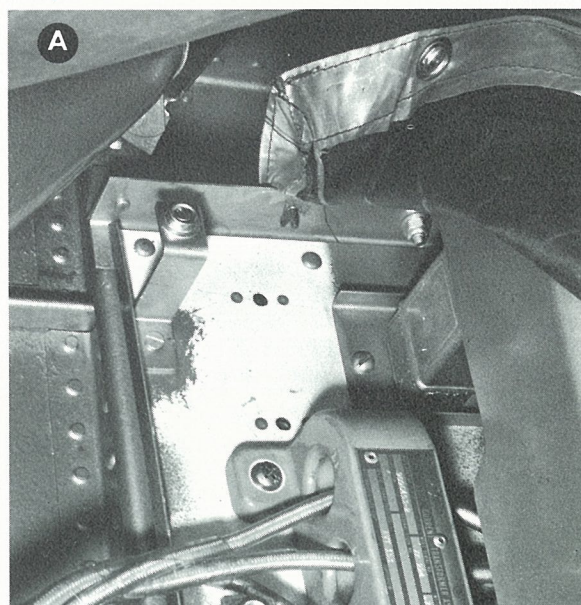
## PROTECTIVE SHIELDS FOR A-C CONTROL PANEL Convair 600/640

One Convair 640 operator installed a cover over the a-c control panel in the right-hand side of each nacelle to deflect runway slush and snow (see photo). Convair-Liner operators may wish to fabricate and install a similar cover to minimize entry of moisture into the electrical components during inclement weather.

The cover is attached to the a-c electrical components support plate by means of snap fasteners that mate with studs installed on angles on the support plate. Convair recommends using a waterproof, fire-resistant material for the cover.

### CAUTION

The cover should be removed during warm weather operation to assure proper cooling of electrical components.



*Protective shield installed over AC control panel in nacelle. Inset shows attaching angles.*

## WATER/METHANOL SYSTEM – CORROSION PROTECTION Convair 600/640

Corrosion products were found in certain areas of the water/methanol system of a Convair 600.

To obviate this condition, operators are cautioned against the use of contaminated solutions. Protection of water/methanol solutions is afforded if the solution is stored in suitable vessels or containers that are internally protected to inhibit corrosion. Stainless steel or glass containers are recommended.

Because of the volatility and hygroscopic nature of methanol, vessels containing the water/methanol solution are to be sealed and stored in a cool place.

There are no technical requirements for a denaturant to be added to the water/methanol solution but, if it is required by law in any locality, Rolls-Royce recommends the use of Pyridine. (See Rolls-Royce Maintenance Manual, Section 70-25, Standard Practices, Specification for Water/Methanol Mixture AEP-1 – W/M Issue 5, Amendment 2, Paragraph 2.B.)

Pyridine, in a solution of 0.5% by volume, acts as a corrosion inhibitor, having a neutralizing effect on acids in solution or in contact with metal surfaces. It effectively protects steel and aluminum surfaces from corrosion if acids are present in the water/methanol solution. No other corrosion inhibitors are approved.

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## ENGINE SELECTOR SWITCH Convair 600/640

Rapid movement of the engine selector switch to the opposite engine after initiating an engine start will transfer power to the selected engine and this engine will start rotating. This occurs without reactivation of the starter switch.

A review of the wiring arrangement indicates that, if the selector switch changeover is rapid, the starting system relays will not drop out during the brief period the selector switch is in the safe position.

Convair realizes that most personnel are aware of the proper procedure for using toggle switches; that is, the switch toggle is firmly grasped, moved to off momentarily, and then moved to the desired position. Snapping the switch from one position to another can result in early failure of the switch.

To preclude incorrect operation with subsequent failure of the switch, it is suggested that the engine selector switch be replaced with a lever lock switch, Cutler-Hammer P/N's 8845-K2, 8859-K56, or equivalent. These switches have a lock in the neutral position which requires a pull on the toggle for actuation. They are directly interchangeable with the present switches.

## INSPECTION OF HATRACK READING LIGHT RECOMMENDED Convair-Liner Aircraft

Convair suggests that operators periodically inspect cabin reading light socket assemblies to insure proper retention and insulation.

This recommendation is created by a cabin smoke incident which resulted from an intermittent electrical short in the hatrack reading light. From examination, it appeared that normal aircraft vibration had caused the reading light socket assembly to work loose and allow the hot terminal to short to the airframe. Normal delay action of the circuit breaker prevented a disconnect of the circuit, the short being intermittent because of airframe vibration.

The heat resulting from the intermittent arc burned a hole in the metal cover and ignited a topcoat in the rack.

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## INSTRUMENT BUGS

The following item appeared in a recent Flight Safety Foundation Newsletter and it prompted reprint of an item carried in the November/December 1962 issue of the Convair Traveler.

Every few months the Flight Safety Foundation calls pilots' attention to the dangers of misreading altimeters. Recently, a former airline check pilot and safety officer addressed a letter to FSF, suggesting a safety assist he felt worthy of investigation. He wrote, "During my check activities of the past, I have been aware of the obvious inability of pilots, due to the myriad of distracting influences, to adhere to the minimum safe approach altitudes. Pilot distraction, i.e., instrument scanning, mental processes and other factors, often make the vague minimum safe altitude easy to descend through on the altimeter.

"In an initial attempt to correct this problem, I suggested the use of a white or yellow grease pencil to mark two lines on the face of the altimeter to denote the ground and also the minimum safe approach altitude. Keeping a sample on my person, I offered its use and found that this corrected the problem in almost every case.

"Realizing this grease pencil has its limitation (primarily its absence when needed), I suggested the use of a ring and double 'bug' mounted on the altimeter, one bug colored white and the other, a reddish color to denote the ground. For a more positive display of altitude limits, the bug should be 5/8-inch in size.

"This idea met with favorable responses from many airline pilots, and I understand a couple of airlines have started using the bugs. To me, the importance of this device is such that it should be a mandatory requirement for air carriers. A pilot simply cannot be expected to find some vaguely defined point on the altimeter under such diverse circumstances. As simple and inexpensive as this 'device' is, I think it would serve as a great safety aid."

We agree...and contacted two instrument companies who replied that they "make altimeters to suit user requirements." One stated his company was not inclined to put development

money into the idea, even though it had a potential, and that an airline would have to order it to get it.

Even though FSF's pursuit of the offered idea has not turned up much, we do know one instrument maker is hard at work developing a low-altitude warning device for the altimeters his company makes for airlines.

• • • • •

A SIMPLE EXTERNAL INDEXING POINTER, or position marker, has been designed by Convair for use on instruments that are not equipped with internal adjustable markers or a "bug," as it is commonly called. The external bug, designed to snap over the outer rim of standard, round, clamp-mounted type instruments, is adjustable. These external indexing pointers can be attached to various instruments as an assist for quick instrument reading.

On the Convair 990, for example, the aft fan engines permit a "rolling" takeoff, in which no stop is made on the runway or taxi strip for individual engine runup and check. Instead, the pilot rolls from the taxi strip onto the takeoff run. At 80 knots, he checks engine pressure ratio and fan rpm for engine power performance for each engine. If engine power output for the four engines is satisfactory, he accelerates to  $V_1$  and makes his takeoff.

Checking engine pressure ratio and fan rpm involving eight instruments, although not difficult, is time-

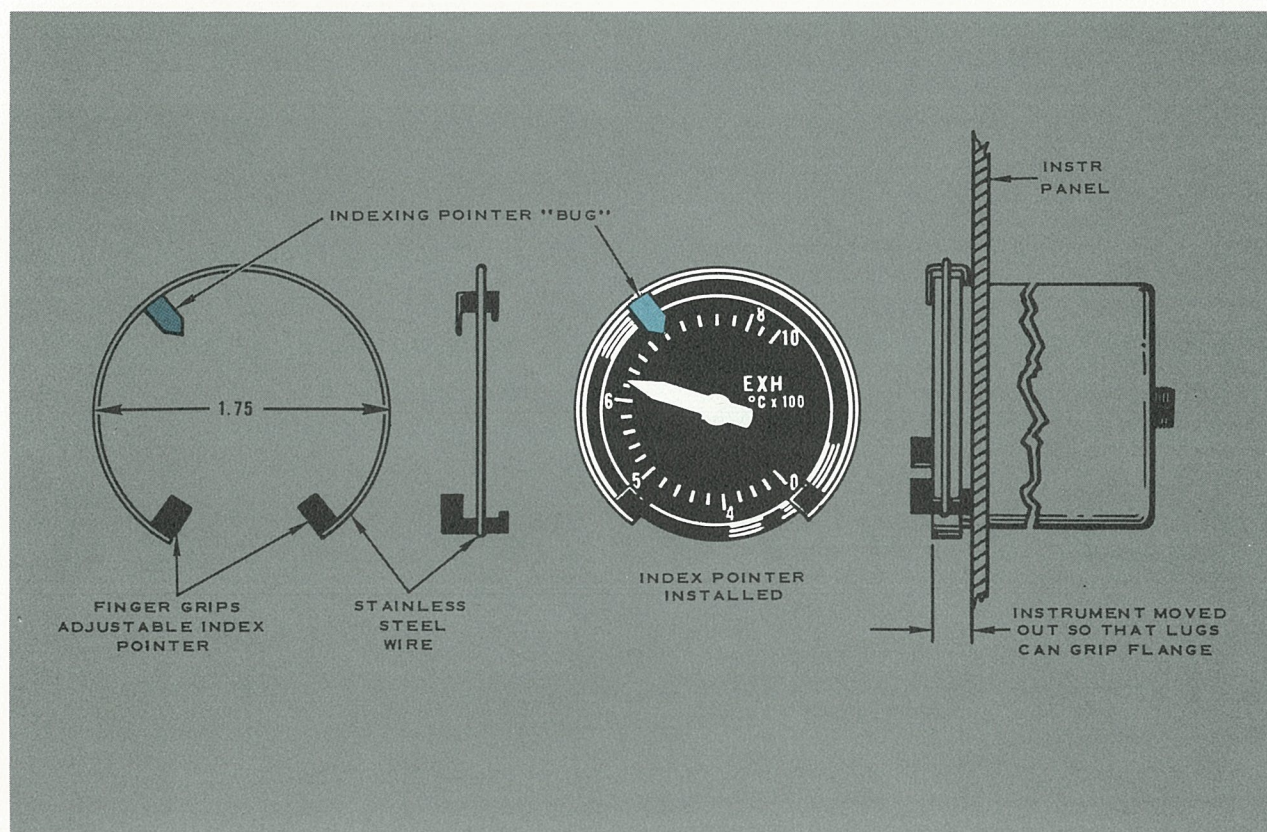
consuming and attention-arresting. With installation of the "bug" this checking of instruments is simplified and facilitated.

The indexing device, for installation on standard, round, clamp-mounted instruments, consists of an arc of stainless steel wire to which are attached three small lugs. Two of these, black in color, protrude to provide finger grips for adjusting; the third, painted white and slightly pointed, becomes the "bug."

To install an indexing bug on a standard, round, clamp-mounted instrument, all that is necessary is to loosen the instrument clamp on the back of the panel, and slightly ease the instrument out of the panel until the lugs on the indexing device can engage the bezel around the rim of the instrument. Then the instrument clamp is retightened.

#### Note

The instrument bug may be ordered through Convair Service Parts Department, specifying P/N 30-91975-1. This device is suitable for installation on any round, clamp-mounted instrument of approximately 1.75 to 2.00 inch diameter.



*Details of instrument bugs fabricated by Convair.*



# Pacific Western Airlines

## *Heavy Airlift Specialist*

Whether traveling for business or pleasure, in small or large groups, to the next way-point or around the world, Pacific Western Airlines is equipped to handle the job.

PWA, which began operation in 1946 as an air charter line and, which today, is the third largest airline in Canada, offers scheduled, contract, and charter flights over regional, national, and international routes, carrying both passengers and freight.

This "heavy airlift specialist" has contracted for many and various jobs...it successfully transported 95% of the entire airlift for the Aluminum Company of Canada's project in British Columbia; was prime contractor for the construction and supply airlift to the DEW line in Western Canada; carried 3000 tons of fuel, cement, and supplies in two months to an airstrip on a glacier high in the Coast Mountains; flew oil drilling crews and equipment to the high Arctic Islands; moved an air force station from Vancouver Island to the mainland; transferred an entire settlement, including building materials and all necessary supplies, to a new community.

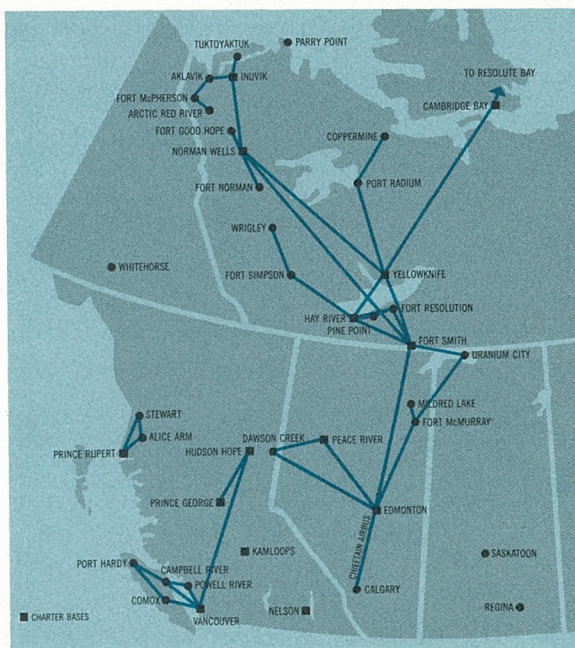
To handle these many tasks in all kinds of weather over any terrain, PWA aircraft are equipped with floats, skis, wheels, or wheel-skis for operation from glaciers, lakes, or improved airstrips to bring even the most isolated areas within all-season reach.

The year 1959 was an important one for PWA. In the largest single transfer of scheduled services in Canadian aviation history, PWA took over Canadian Pacific Airlines routes, extending from Edmonton, Alberta, to 18 northern points. With these additional routes, the company was licensed to fly some 7,000 scheduled unduplicated route miles throughout western and northern Canada, serving 30 communities in British Columbia, Alberta, Saskatchewan, and the Northwest Territories.

These comprehensive main-line routes extend from three unconnected company-operated centers in Vancouver, Edmonton, and Prince Rupert, with Edmonton being the hub of the main-line traffic.

International charters and contract flights remain an important factor in the airline's operation.

To update its fleet and take care of expanding traffic, this completely unsubsidized airline has purchased four Convair 640's. These aircraft with Rolls-Royce turboprop engines are ideally suited for PWA's route structure and all-weather operation. The first of these aircraft entered scheduled operation on March 19. The 640's will operate on routes out of Edmonton and Vancouver.



**GENERAL DYNAMICS**  
*Convair Division*